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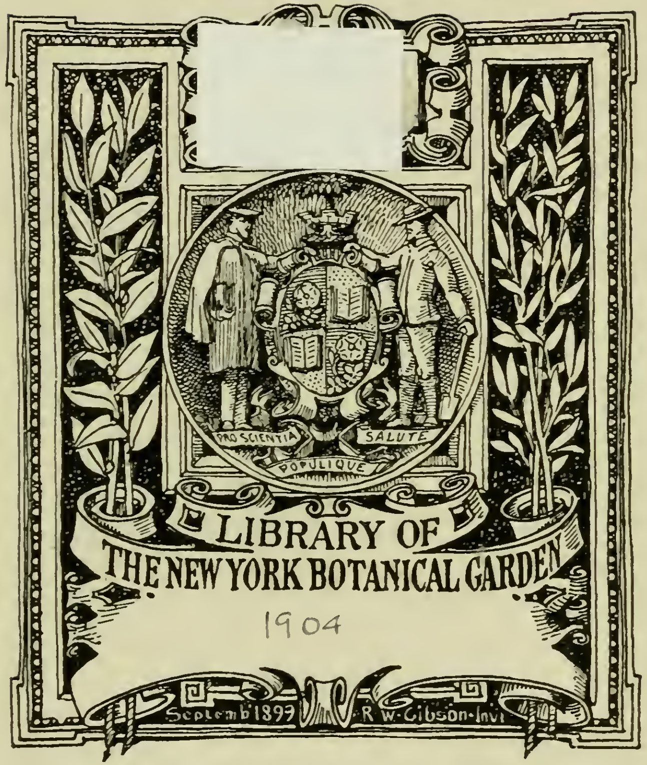
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VOLUME II

1902–1904

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 26

CHEMICAL STUDIES OF THE COCOANUT WITH SOME NOTES ON THE CHANGES DURING GERMINATION

BY J. E. KIRKWOOD AND WILLIAM J. GIES

NEW YORK
1902

[Reprinted from BULLETIN TORREY BOTANICAL CLUB, **29**: *321-359*, 20 June, 1902.]

Chemical Studies of the Cocoanut with some Notes on the Changes during Germination *

By J. E. Kirkwood and William J. Gies

(With Plate 19)

[From the Laboratory of Physiological Chemistry of Columbia University, and the New York Botanical Garden, New York.]

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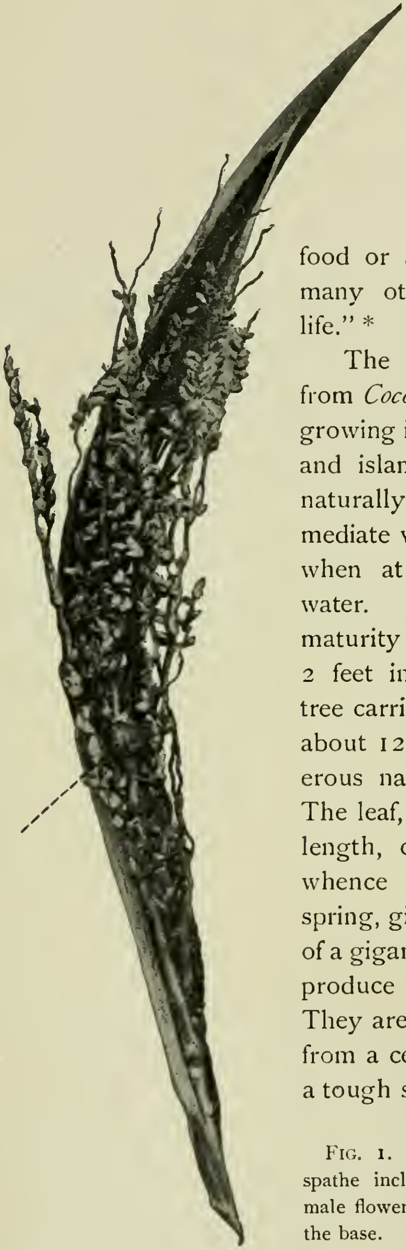
* Preliminary accounts of some of the results of this research were given in the Proceedings of the American Association for the Advancement of Science, — : 275. 1900, and in the Proceedings of the American Physiological Society. 1900 : American Journal of Physiology, 5 : 14. 1901.

The term "coco" appears to be derived from "coc" or "cocus," a local name for the "Indian nut," the fruit of *Cocos nucifera*, given to it on account of a fancied resemblance of the base of the endocarp, with its three circular impressions, to the face of a monkey when it utters a cry having a sound like the word. See *f. 1, pl. 19*. The term "cocoa" should be carefully distinguished from "cacao," the product of *Theobroma cacao*, from "coca" the derivative of *Erythroxylon coca*, from "coco," the coco-kola of commerce, and from "cocco" or "cocoa root" (*Colocasia esculenta*).

[Issued 20 June]

I. INTRODUCTION



"Of the whole class of seeds having the character of luxuries rather than of necessaries, the cocoanut is by far the most important to mankind, whether considered as a delicious and nutritious food or as supplying valuable oil and many other articles useful in social life." *

The common cocoanut is derived from *Cocos nucifera*, a species of palm growing in practically all tropical coasts and islands. The cocoa palm grows naturally on the seashore or in its immediate vicinity and does not bear well when at a great distance from salt water. (See analyses, p. 335.) At maturity it has a cylindrical stem about 2 feet in diameter. At its apex the tree carries a tuft of leaves, which are about 12 feet long. These have numerous narrow, rigid and long leaflets. The leaf, which may attain to 20 feet in length, consists of a strong mid-rib, whence numerous long acute leaflets spring, giving the whole the appearance of a gigantic feather. The flowers which produce the nut are yellowish-white. They are arranged in spikes, branching from a central axis, and inclosed with a tough spathe usually a meter or more

FIG. 1. Inflorescence of the cocoanut showing spathe inclosing the spikes, each with numerous male flowers above and a single female flower near the base. × $\frac{1}{5}$. Winton.

---

* Smith: Food, 226. 1873.

in length. Their appearance and arrangement is shown in Fig. 1, on the opposite page. The tree grows to a height of about 60–100 feet and usually bears 80–100 nuts arranged on the tree in bunches of 10–20. It continues to bear during two generations of men.

The fruit is subtriangular-ovoid in form, about 12 inches long and 6 inches broad. It is composed of a thick, fibrous "husk" (exocarp) and thin, hard "shell" (endocarp), containing a white fleshy seed, the "meat" (endosperm), with a thin integument (testa). (See *Fig. 3*, p. 324.) The thick husk is remarkably adapted to the preservation of the seed, whilst the nut is tossed about by the waves until it reaches some shore, it may be, far distant from that on which it grew. While immature the nut is without the solid endosperm, but is filled with a milky fluid. As it ripens, however, the endosperm gradually develops and the milky juice diminishes in quantity. The temperature of this juice when fresh is always comparatively low. (See page 349 for further reference to the parts of the nut.)

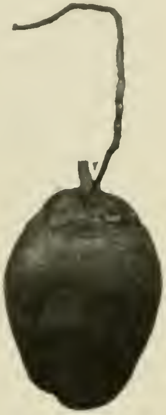


FIG. 2. Half-grown cocoanut fruit with calyx, and axis from which the male flowers have fallen. × $\frac{1}{5}$. Winton.

Figures 1, 2 and 3 are from cuts loaned to us by Dr. A. L. Winton, who used them lately in the account of his very valuable histological study of "The Anatomy of the Fruit of the *Cocos nucifera*."* We are greatly indebted to Dr. Winton for his kind assistance.

The cocoanut forms the chief food of the inhabitants of Ceylon, the South Sea Islands, the coast of Africa and other tropical coasts and islands.† The flesh is not only eaten as it comes from the tree, both ripe and unripe, but it is also prepared and served in various ways. In India the "copra" is much used as an ingredient of curries. It forms an accessory part of the diet, and is found in many of the confections, of civilized man all over the globe.*

---

* Winton : American Journal of Science, IV. **12** : 265. 1901.

† The cocoanut is agreeable to the taste of various domestic and other animals, and is eagerly eaten by them. The cocoanut-crab (*Birgus latro*, suborder *Macrura* ; anomalous form, approaching the *Brachyura* and closely related to the hermit crab) feeds almost entirely on the kernel of the cocoanut. Its powerful claws enable it to easily peel off the husk and open the hard shell.

Immoderate use of the fruit, which according to the people of the tropics is highly refrigerant, causes, it is said, rheumatic and other diseases.† The milk is considered an agreeable cooling beverage in the tropics. It has been known for some time that irritation of the mucous membrane of the bladder and urethra is caused by drinking too freely of the cocoanut milk.‡ It is strongly diuretic. Parisi has used the cocoanut therapeutically as an anthelmintic with uniformly satisfactory results.§ He states that the meat of the nut is a powerful *taenicide*, the milk sharing the prop-

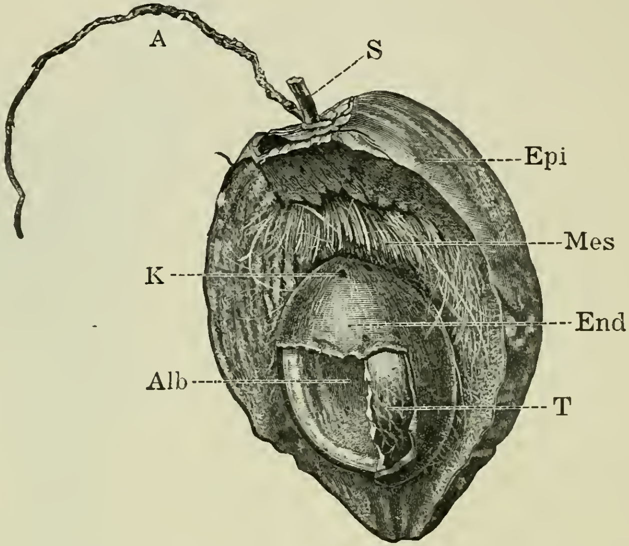


FIG. 3. Ripe cocoanut. *S*, lower part of axis forming the stem; *A*, upper end of axis with scars of male flowers; *Epi*, epicarp; *Mes*, mesocarp with fibers; *End*, endocarp or hard shell; *T*, portion of testa adhering to endosperm; *Alb*, endosperm surrounding cavity of the nut; *K*, germinating eye. × $\frac{1}{5}$. Winton.

---

* In the Annals of the New York Academy of Science, 13: 490, 1900–1901, the following may be found: "Dr. Gies in answer to a question stated that the food content of the cocoanut is small." This answer is quoted incorrectly. The question referred to the *nitrogenous* food content. It was stated on that occasion that the "content of *proteid* food-stuff is small." See page 340.

† Pavy: A Treatise on Food and Dietetics physiologically and therapeutically considered, 488. 1878.

‡ Curtis: Annals of the New York Academy of Sciences, 13: 490. 1900–1901.

§ See Liebreich: Encyklopaedie der Therapie, 1: 744. 1896.

erty.* The cocoanut has been used as a vermifuge in India for probably forty generations by the beef eaters of that country and is there well known as a means of expelling the flat worm.† The small, green and immature nut is grated fine for medicinal use, and when mixed with the oil of the ripe nut becomes a healing ointment.

The fibrous husk (coir) is widely used for the construction of ropes, brushes, bags, matting, etc. The compact fleshy edible portion (copra), closely lining the hard shell and which is entirely fluid or gelatinous when young, contains a large proportion of fat, which is extracted and used for various commercial purposes, such as the manufacture of fine soaps and candles and frequently as a substitute for butter. Cocoanut oil and resin melted together yield a substance capable of being used with success in filling up the seams of boats and ships, and in tropical countries for covering the corks of bottles as a protection against the depredations of the white ant. A quart of the oil may be obtained from six to ten nuts. The hard shell is easily polished and lends itself to the formation of various utensils and ornaments. It also has a high fuel value.

Although considerable is known of the constituents of the cocoanut, of its nutritive value and commercial uses, little has been done to ascertain the nature of the changes which the nut undergoes during germination. At the suggestion of Dr. MacDougal we have undertaken such a study, more especially from the chemical standpoint, and although our work in this particular connection has not been quite as fruitful as we had hoped it might be, our results are not without some interest.

II. CHEMICAL COMPOSITION OF THE UNGERMINATED COCOANUT

Before beginning our work on the germinating seed we felt it desirable to make ourselves thoroughly familiar with the chemical qualities of the ungerminated nut. This seemed all the more desirable because of the incomplete as well as the disconnected chemical data thus far recorded in this connection. This purpose was accomplished in a large number of analyses of numerous samples. We record the more important of these results, with comparative data from the work of others, on the following pages.

---

* United States Dispensatory, 1619. 1899.

† American Journal of the Medical Sciences, 67 : 281. 1889.

Most of the nuts subjected to the analyses referred to farther on were furnished to us for this work by Hon. Wm. Fawcett and the United Fruit Co., who sent them in their husks from Jamaica. They were ripe, fresh and of about the average size. A few determinations were made with material from nuts bought in the markets in this city—source unknown, though doubtless of West Indian origin. These were of ordinary size, appeared to be ripe and fresh, and gave essentially the same analytic results as those obtained directly from Jamaica.[*]

We wish at the outset of this paper to thank Dr. MacDougal not only for the supply of material with which he favored us, but also for the suggestions which led us to undertake this work and for the kind encouragement he has given us from the beginning.

PROPORTIONS OF MILK, ENDOSPERM AND SHELL IN THE HUSKED NUT.—The weights and proportions of the main parts of the nut without its husk were carefully ascertained in special observations, as well as incidentally in other experiments.[†] The milk was removed as indicated on page 328. The empty nut was quickly broken with a hammer, the endosperm and germ, with the thin seed coat, carefully and promptly removed with a knife, and the fresh moist parts weighed at once. The results given on the opposite page were obtained in this connection.[‡]

The only results recorded on these gross relationships that we have been able to find were those obtained in a single experiment by v. Ollech, and those by Bachofeu.[§] The parts of a single cocoanut, except the milk, were dried in the air by v. Ollech.[||]

---

[*] A few showed signs of deterioration, such as "popping" on opening, free acid in the milk, etc. These were, of course, discarded.

[†] The weight of the fibrous husk varies considerably, as the amount of moisture increases by absorption or decreases by evaporation. The weights of the other parts are ordinarily not subject to such fluctuations.

[‡] The weights of the germ and the thin seed coat enveloping the endosperm were included with the latter.

[§] See also Berzelius: Lehrbuch der Chemie. Translated by Wöhler, 7: 533. 1838.

[||] v. Ollech: Quoted by König, Die menschlichen Nahrungs- und Genussmittel, etc., 2: 495. 1893.

FRESHLY IMPORTED NUTS (FROM JAMAICA).

Number.	Weights in Grams.				Percentage of total Weight of husked Nut.			Milk.	
	Fruit without Husk.	Shell.	Endosperm with Germ and Integument.	Milk.	Shell.	Endosperm with Germ and Integument.	Milk.	Vol. c.c.	Specific Gravity.
1	845	255	437	153	30.2	51.7	18.1	150	1018
2	771	198	379	194	25.7	49.2	25.1	190	1017
3	658	168	371	119	25.5	56.4	18.1	117	1020
4	718	199	351	168	27.7	48.9	23.4	164	1019
5	597	152	327	118	25.5	54.8	19.7	113	1022
6	463	127	251	85	27.4	54.2	18.4	83	1019
7	622	195	334	93	31.3	53.7	15.0	90	1023
8	563	144	329	90	25.6	58.4	16.0	87	1027
9	633	166	374	93	26.2	59.1	14.7	90	1027
10	530	156	282	92	29.4	53.2	17.4	90	1021
11	637	150	363	124	23.5	57.0	19.5	121	1024
12	497	144	267	86	29.0	53.7	17.3	85	1014
13	538	162	283	93	30.1	52.6	17.3	90	1021
14	413	123	256	34	29.8	62.0	8.2	33	1030
15	511	158	309	44	30.9	60.5	8.6	43	1037
16	578	190	320	68	32.8	55.4	11.8	67	1016
17	568	142	350	76	25.0	61.6	13.4	74	1026
18	495	140	293	62	28.3	59.2	12.5	60	1024
19	813	221	392	200	27.2	48.2	24.6	194	1021
20	758	208	393	157	27.4	51.9	20.7	150	1022
21	584	148	339	97	25.4	58.0	16.6	94	1028
Aver.	609	169	333	107	27.8	55.2	17.0	104	1023

NUTS FROM THE MARKET (NEW YORK CITY).

1	1070	250	558	262	23.4	52.2	24.4	254	1018
2	1009	251	506	252	24.9	50.1	25.0	246	1015
3	728	202	417	109	27.7	57.3	15.0	106	1027
4	800	226	450	124	28.2	56.3	15.5	120	1026
5	688	191	385	112	27.8	56.0	16.2	110	1015
6	565	131	316	118	23.2	56.0	20.8	116	1017
7	639	210	382	47	32.9	59.8	7.3	46	1024
8	638	210	311	117	32.9	48.8	18.3	115	1017
9	480	125	304	51	26.0	63.3	10.7	48	1034
10	561	158	307	96	28.2	54.7	17.1	92	1024
11	733	204	414	115	27.8	56.5	15.7	110	1024
12	762	176	380	206	23.1	49.9	27.0	202	1020
Aver.	722	194	394	134	27.1	55.1	17.8	130	1021

They represented the following proportions of the total weight, which was 1,133 grams:

Fibrous Husk.	Shell.	Endosperm with Germ.*	Milk.
30.45 per cent.	19.59 per cent.	37.78 per cent.	12.18 per cent.

Of the total weight of the husked nut, which, by calculation, must have been 788 grams, the percentages of the parts were (calculated by us):

---

* Including, doubtless, the seed coat as well.

Shell.	Endosperm with Germ.	Milk.
28.17 per cent.	54.32 per cent.	17.51 per cent.

These results, it will be observed, harmonize closely with the averages of our own determinations.

The data obtained by Bachofeu in this connection will be found in the table on page 335.*

COMPOSITION OF THE MILK.—The milk was poured from the nut through an opening made in the "eye" of the fertile carpel (see page 350) with a cork-borer. Extraneous matter could easily be kept out of the milk by this procedure and, besides, the fluid could be obtained when desired in a perfectly fresh, unevaporated condition.

The milk was found to be faintly turbid and opalescent in each case, and always contained a few oil globules and occasionally crystalline matter. It was acid in reaction to litmus although, as shown by lacmoid, no free acid was present in the normal fluid. The reaction is due to acid phosphate. Both alkali and earthy phosphate are present. The latter can be precipitated, in part at least, on boiling. An abundant precipitate of phosphate is obtained when the milk is made alkaline. The average specific gravity, determined with the aid of a hydrometer, was, as already noted on page 327, 1,023 and 1,021. The average specific gravity of the mixed milk of 15 nuts not included in the table on that page was 1,023. Of eight additional nuts not referred to there, and examined at another time, the figures for the mixed milk were 1,022.

The milk reduces Fehling's and Nylander's solutions and it ferments. It contains some monosaccharide which, from the characters of the phenylosazone derivatives, appears to consist of either dextrose or galactose, probably of both. Disaccharide in the form of cane-sugar is also present in good quantity, as might be inferred from the sweet taste of the milk.

---

* Results having some relation to these are given by Atwater: Report of the Storrs (Conn) Agricultural Experiment Station, 123. 1899. Hammerbacher (Landwirtschaftlichen Versuchs-Stationen, etc., 18: 472. 1875) found that the endosperm of two nuts weighed 835.8 grams; the milk, 303.95 grams. See also, pages 331 and 356.

On standing the milk turns sour, becomes thicker, and has much the odor and physical appearance of soured cow's milk. The milk ferments readily. As it does so the acidity increases with a production of acid from the sugar. Alcohols are also produced in the process. The distillate from the fermented milk has an agreeable taste and an alcoholic odor.*

Chlorides are prominent with phosphates among the inorganic substances of the milk. It contains only a very small quantity of proteid, coagulating above 80° C., and also traces of a proteose-like body. Very faint biuret and xanthoproteic reactions were obtainable with the fresh fluid. A snow-white precipitate consisting in part of earthy phosphate is obtained on warming the milk on the water-bath at 70° C. The filtrate from this product when boiled yields a delicate turbidity of coagulated proteid which becomes flocculent on addition of a slight excess of acetic acid. The filtrate from this coagulum gives only a very faint biuret reaction. Cocoanut milk is said to contain malate of lime.†

GENERAL COMPOSITION OF THE MILK

	Milk Used.		Percentage of Fresh Milk.				Percentage of Solids.	
No.	Specific Gravity.	Grams.	Water.	Solid Matter.			Organic Matter.	Inorganic Matter.
				Total.	Organic.	Inorganic.		
1–*a*	1019	28.815	95.52	4.48	3.98	0.50	88.84	11.16
b		27.280	95.43	4.57	4.05	0.52	88.60	11.40
2–*a*	1020	25.403	95.28	4.72	4.27	0.45	90.58	9.42
b		27.837	95.44	4.56	4.14	0.42	90.70	9.30
3–*a*	1022	30.382	94.73	5.27	4.78	0.49	90.57	9.43
b		28.528	94.62	5.38	4.90	0.48	91.02	8.98
4–*a*	1016	25.958	95.73	4.27	3.88	0.39	90.81	9.19
b		25.823	95.65	4.35	3.96	0.39	90.92	9.08
c		26.298	95.68	4.32	3.91	0.41	90.57	9.43
5–*a*	1021	29.416	95.11	4.89	4.47	0.42	91.38	8.62
b		29.467	95.23	4.77	4.36	0.41	91.39	8.61
c		24.667	95.24	4.76	4.35	0.41	91.31	8.69
6–*a*	1024	23.119	95.44	4.56	3.82	0.74	83.68	16.32
b		23.886	95.33	4.67	3.92	0.75	84.04	15.96
7–*a*	1028	22.540	94.80	5.20	4.18	1.02	80.38	19.62
b		26.690	94.94	5.06	——	——	——	——
8–*a*	1027	28.722	95.02	4.98	4.21	0.77	84.45	15.55
b		28.409	94.97	5.03	4.26	0.77	84.69	15.31
Aver.	1022	26.847	95.23	4.77	4.21	0.56	88.47	11.53

---

* Cocoa beer, containing 3.4 per cent. "Extractive," has been made by Calmette: Chemisches Centralblatt, **2**: 394. 1894.

† Harley and Harley: Proceedings of the Royal Society of London, 43: 464. 1887–88.

On evaporation to a small volume on a water-bath the fresh milk becomes darker in color, takes on an odor characteristic of sugar syrups and looks not unlike molasses. Cane-sugar crystallizes from it in abundance on cooling.

The analytic data given on page 329 were obtained in our study of the general composition of the perfectly fresh milk of the Jamaican nuts.[*]

Percentage results in this connection had been obtained previously as follows:

Water.	Solids.	Organic Matter.	Inorganic Matter.	Nitrogenous Substance.	Fat.	Nitrogen-free Extractives	Carbohydrates.
91.50[†]	8.50	7.31	1.19	0.46	0.07	6.78	—
91.37[‡]	8.63	7.50	1.13	0.38	0.11	—	7.01[§]

These results were obtained with milk from nuts grown in the eastern hemisphere. The milk from the Jamaican nuts appears, as we have seen, to contain less solid matter, both organic and inorganic. This difference is emphasized by Hammerbacher's[¶] observations on the specific gravity of cocoa-milk. He describes the milk as a colorless, slightly opalescent fluid with a specific gravity at 20° C. of 1044.[**] The milk from two nuts weighed 303.95 grams. From the nitrogen-free extractive substance in 77.8 grams of milk contained in a third nut, 0.8504 gram of dextrose was obtained. When milk was warmed with dilute sulphuric acid an odor of volatile fatty acid became perceptible. A crystalline barium salt was prepared from the distillate of the acidified milk which was found to consist of barium propionate.

The milk contains a small amount of diastatic ferment and also oxidase.[††] We were unable to detect any other enzymes.

The following results were obtained by van Slyke[‡‡] in his comparative studies of the milk of six *unripe* nuts and of one ripe one:

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[*] The methods of analysis used for this and similar purposes, throughout our work, were those commonly employed in the laboratory. See Vandegrift and Gies: American Journal of Physiology, 5: 287. 1901.

[†] Hammerbacher: Landwirtschaftlichen Versuchs-Stationen, etc., **18**: 472. 1875.

[‡] König: Menschlichen Nahrungs- und Genussmittel, etc., **2**: 308. 1893. See also Bizio: Pharmaceutisches Centralblatt, 756. 1833.

[§] Including 4.42 per cent of cane-sugar. See page 328.

[¶] Hammerbacher, *loc. cit.*

[**] See our large number of determinations of specific gravity on page 327. Also references on pages 328 and 329.

[††] Hunger: Journal of the Society of Chemical Industry, **20**: 1030. 1901.

[‡‡] Van Slyke: Chemisches Centralblatt, **1**: 595. 1891. Compare with results on page 329.

Constituents.	Milk of unripe Nuts.							Milk of ripe Nut.
	1	2	3	4	5	6	Average 1–6.	
Weight in grams. . .	230.5	378.6	347.0	383.7	350.0	330.0	336.6	109.6
Specific gravity . . .	1,024.6	1,023.0	1,022.3	1,023.0	1,022.1	1,021.5	1,022.8	1,044.0
Water (per cent.)	94.37	94.48	94.59	94.89	95.27	96.43	95.01	91.23
Total solid matter (%)	5.63	5.52	5.41	5.11	4.73	3.57	4.99	8.77
Inorganic substance.	0.575	0.635	0.675	0.611	0.658	0.602	0.626	1.06.
Glucose	4.58	3.83	3.45	4.06	4.36	3.56	3.97	Trace.
Cane-sugar . . .	Trace	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	4.42
"Albuminoid" . .	0.120	0.126	0.114	0.205	0.140	0.095	0.133	0.291
Fat . .	0.084	0.100	0.138	0.131	0.145	0.120	0.120	0.145

The chief chemical differences induced by growth, as indicated by the above results, are an increase in the proportion of solid matter, including ash, fat and nitrogenous substance. Glucose almost entirely disappears from the milk of the ripe nut, cane-sugar replacing it—a fact evidencing synthetic production of disaccharide from monosaccharide.

Hammerbacher, believing that the endosperm develops directly from the milk, determined the quantitative relationships of the saline matters contained in each part from the same nut. He gives the following as his percentage results:

	Ash of the Milk.	Ash of the Endosperm.*
Potassium,	55.200	43.882
Sodium,	0.728	8.392
Calcium,	3.679	4.628
Magnesium,	6.606	9.438
Chlorine,	10.373	13.419
Phosphoric acid,	20.510	16.992
Sulphuric acid,	5.235	5.091
Silicic acid,	——	0.500
	102.331	102.342
Minus oxygen for chlorine,	2.338	3.024
	99.993	99.318

The above results indicate a particular increase of the content of sodium chloride in the ash of the developing endosperm and a corresponding decrease of potassium phosphate. See pages 322 and 335. The amount of silicic acid in the endosperm is also noteworthy. See page 335.

ENDOSPERM. *General Composition.*—The pure white kernel or "meat" of the nut is fibrous in structure, closely lines the shell, is from 1 to 2 cm. thick, and contains a very large proportion of fat. It is the part used most frequently for dietetic purposes. It possesses a characteristic and pleasant odor and is very agreeable to the taste. The endosperm cells do not contain starch granules, but fat needles and proteid lumps are present in them. The proteid particles are partly crystalline.*

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* Compare with results of Bachofeu's analysis, given on page 335. Our own results were the same as these qualitatively. See also Schaedler Technologie der Fette und Oele des Pflanzen- und Thierreichs, 840, 1892, who found 3.60 per cent. of iron in the ash of the endosperm in addition to the above constituents.

After the kernel has been finely divided in a meat chopper, the resultant hash may be subjected to increasing pressure, when an oily juice is obtained from it. The filtrate from this turbid mixture has a higher specific gravity than the milk of the nut, is acid in reaction, reduces Fehling's solution, contains a dextrin-like body and the milk salts, gives the proteid color reactions, yields coagulable proteid, and on dilution with water becomes turbid from precipitated globulin.

General Composition of the Endosperm

No	Endosperm used.	Percentage of fresh Endosperm.				Percentage of Solids.	
	Grams.	Water.	Solid Matter.			Organic Matter.	Inorganic Matter.
			Total.	Organic.	Inorganic.		
1–*a*	8.467	47.70	52.30	51.19	1.11	97.88	2.12
b	9.728	42.10	57.90	56.79	1.11	98.09	1.91
c	10.900	46.60	53.40	52.34	1.06	98.01	1.99
2–*a*	11.885	48.31	51.69	50.65	1.04	98.01	1.99
b	12.151	48.90	51.10	50.01	1.09	97.87	2.13
c	11.707	52.29	47.71	46.61	1.10	97.69	2.31
3–*a*	8.762	43.90	56.10	55.20	0.90	98.39	1.61
b	8.185	47.73	52.27	51.20	1.07	97.95	2.05
c	8.923	46.31	53.69	52.71	0.98	98.18	1.82
4–*a*	11.511	47.89	52.11	51.05	1.06	97.97	2.03
b	9.501	46.90	53.10	52.05	1.05	98.02	1.98
c	9.244	47.50	52.50	51.43	1.07	97.96	2.04
5–*a*	8.942	42.80	57.20	56.17	1.03	98.21	1.79
b	9.312	43.79	56.21	55.21	1.00	98.23	1.77
6–*a*	10.214	50.30	49.70	48.68	1.02	97.95	2.05
b	10.624	48.70	51.30	50.28	1.02	98.02	1.98
7–*a*	10.746	42.21	57.79	56.83	0.96	98.34	1.66
b	10.142	39.60	60.40	59.46	0.94	98.45	1.55
Aver.	10.052	46.31	53.69	52.66	1.03	98.07	1.93

The data given above were obtained for general composition of the endosperm immediately after the nuts were opened.†

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* See pages 342 and 352.

† The methods were the same as those employed with the milk. The thin seed-coat was trimmed off and the pieces of kernel cut into small, thin pieces with a knife. The material was taken from all parts of the nut.

Comparison of the averages given on the opposite page may be made with the following previously recorded results for the fresh endosperm from nuts of eastern origin :[*]

FRESH ENDOSPERM				DRY ENDOSPERM	
Water.	Total Solids.	Organic Matter.	Inorganic Matter.	Organic Matter.	Inorganic Matter.
46.64	53.36	52.39	0.97	98.20	1.80

The agreement is seen to be very close.

By reason of the dietetic and commercial values of the various constituents of the endosperm of the cocoa fruit, numerous products of the kernel have been made and analyzed. The air-dried endosperm, or so-called "copra," is shipped in large quantities from the tropics. Cocoa-oil is obtained from the copra by various methods in countries distant from the tropics, the solid residues remaining after extraction serving various purposes. This residue makes up the so-called "cocoa-cake" obtained in the process of expressing the oil at various degrees of temperature. It is also ground into "cocoa-meal." In both forms, the residual substance

Products Analyzed.	Water.	Total Solids.	Organic Matter.				In-organic Matter.
			Nitrogenous Substance.	Fat.	N-free Extractive.	Crude Fiber.	
Air-dried endosperm or copra.[†]	5.81	94.19	8.88	67.00	12.44	4.06	1.81
Endosperm, perfectly dried.[‡]	——	100.00	10.29	67.35	15.11	5.42	1.83
Endosperm, free from fat and water.[‡]	——	100.00	31.49	——	46.25	16.69	5.57
"Cocoa-cake."[§]	10.30	89.70	19.70	11.00	38.70	14.40	5.90
"Cocoa-meal."[‖]	11.12	88.88	17.94	10.88	35.34	17.40	7.32
"Cocoa-meal," after extraction of oil.[¶]	4.55	95.45	23.20	1.85	64.45		5 95

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[*] Hammerbacher : Landwirtschaftlichen Versuchs-Stationen, etc., 18 : 472. 1875. See also Bizio : Pharmaceutisches Centralblatt, 757. 1833.

[†] König : Menschlichen Nahrungs- und Genussmittel, etc., 2 : 652. 1893. Also p. 308.

[‡] Hammerbacher : Landwirtschaftlichen Versuchs-Stationen, etc., 18 : 472. 1875.

[§] Dietrich und König : Zusammensetzung und Verdaulichkeit der Futtermittel; 2 : 1031. 1891.

[‖] Dietrich und König : *ibid.*, 1 : 725.

[¶] Schaedler : Technologie der Fette und Oele des Pflanzen- und Thierreichs, 624. 1892. (*a*) For references to digestibility and nutritive value of cocoa-cake see results of experiments on pigs and sheep given by Dietrich and König, 2 : 1031, 1036, 1040, 1123. (*b*) Compare above results with the table for general composition on the opposite page.

is used as food for cattle and as a fertilizer, having special value in both these connections.* It is sometimes also used illicitly as a food adulterant.

The analytic percentage results on page 333 have been reported by various agricultural chemists for such products from nuts grown in the eastern hemisphere.

The following summary of facts connected particularly with food value was given several years ago by Woods and Merrill: †

	Refuse.	Water.	Proteid.	Fat.	Total carbohydrates.	Ash.	Fuel value per pound; calories.
Edible portion,	——	14.1	5.7	50.6	27.9	1.7	2,986
As purchased,	48.8	7.2	2.9	25.9	14.3	.9	1,529
Without milk, as purchased,	37.3	8.9	3.6	31.7	17.5	1.0	1,872
Cocoanut milk, as purchased,	——	92.7	.4	1.5	4.6	.8	97
Shredded cocoanut,	——	4.3	6.5	63.7	24.1	1.4	
Shredded cocoanut,	——	2.8	6.0	51.0	39.0	1.2	
Edible portion,	——	5.8	8.9	67.0	16.5	1.8	
Cocoanut milk,	——	91.5	.5	.1	6.8	1.2	

Through the kindness of Dr. MacDougal we have been able to examine an account of "The cocoanut and plant vitality" in the Bulletin of the Botanical Department of Trinidad (July, 1900, p. 249). Reference is therein made to the report of Bachofeu in the Queensland Agricultural Journal for April, 1900. Bachofeu says: "Though there exist several analyses of parts of the cocoanut, no one seems to have undertaken the task of getting a complete analysis made with the view of ascertaining the actual demand made by the cocoanut upon the mineral constituents of the soil."

The results obtained by Bachofeu for a single nut are so complete, and so general in their interest and application that we quote, on page 335, his general summary in its entirety. ‡

Bachofeu's results indicate that sodium chloride and potassium phosphate are the chief inorganic matters drawn upon in the development of the cocoanut—chemical data in harmony with the fact that the cocoa palm does not thrive away from the coast or where salt is lacking in the soil. See second table, page 331.

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* v. Knieriem: Chemisches Centralblatt, 2: 672. 1898.

† Woods and Merrill: Bulletin, Maine Agricultural Experiment Station, No. 54; 81. 1899.

‡ The analyses were made in Ceylon. Native nuts were used.

BACHOFEU'S ANALYSIS OF THE COCOANUT

	Husk.	Shell.	Kernel.	Milk.
Total weight in lbs.	2.702	0.546	0.875	0.593
" " in per cent.	57.28	11.59	18.54	12.58
* { Moisture in per cent.	65.56	15.20	52.80	——
{ Dry matter in per cent.	34.44	84.80	47.20	——
Pure ash in per cent., containing viz :	1.63	0.29	0.79	0.38
Silica, SiO_2.	8.22	4.64	1.31	2.95
Oxide of iron and alumina, $Fe_2O_3Al_2O_3$.	0.54	1.39	0.59	Trace.
Lime, CaO.	4.14	6 26	3.10	7.43
Magnesia, MgO.	2.19	1.32	1 98	3.97
† Potash, K_2O.	30.71	45.01	45.84	8.62
Soda, Na_2O.	3.19	15.42	——	——
† Potassium chloride, KCl.	——	——	13.04	41.09
Sodium chloride, NaCl.	45.95	15.56	5.01	26 32
Phosphoric acid, P_2O_5.	1.92	4.64	20.33	5.68
Sulphuric acid, SO_3.	3.13	5.75	8.79	3.94
	100.00	99.99	99.99	100.00
† Containing total potash, K_2O.	30.71	45.01	54.05	34.54
* Containing nitrogen, N.	0.137	0.100	0.504	——

Thus of the more important ingredients of the soil 1,000 nuts remove the following :

In Lbs.	Husk.	Shell.	Kernel.	Milk.	Total Lbs.
Nitrogen, N.	3.7017	0.5460	4.4100	——	8.6577
Phosphoric acid, P_2O_5.	0.8456	0.0735	1.4053	0.1279	2.4523
Potash, K_2O.	13.5255	0.7127	3.7362	0.7783	18.7527
Lime, CaO.	1.8234	0.0991	0.2143	0.1674	2.3042
Sodium chloride, NaCl.	20.2375	0.2464	0.3563	0.5431	21.4233

Fat.—The striking chemical characteristic of the endosperm is its large content of oil. This may readily be extracted with fluids like ether. It can also be obtained in large proportion by pressure, particularly at the tropical temperatures. The fat has the consistence of butter in northern countries and possesses, when fresh, a fragrant and characteristic odor and an agreeable taste. It is snow white, sometimes cream-colored and readily crystallizes in large rosettes from the molten condition or from its alcohol or ethereal solutions. These crystals closely resemble those of palmitic acid. They melt at about 20–23° C., and congeal again several degrees below the melting point. They are fairly soluble in cold alcohol. Although cocoa-fat differs somewhat in composition in different countries, it has been found that the variations are comparatively slight. The temperature at which the oil is expressed influences these variations by increasing or decreasing the proportion of fats melting only at higher temperatures. These facts account for the variations in the figures given for melting point. Its specific gravity is 0.9+.

On heating to about 170° C., the oil gives off the odor of lactic acid; at a temperature of 300° C. acrolein may be detected. On long-continued heating with nitric acid the following dibasic acids are formed: succinic, adipic, pimelic, suberic and azelaic. Nitrocaproic acid is also formed.* The oil is very soluble in all of the well-known fat solvents. It contains some free fatty acid, but consists chiefly of glycerides of caprylic, lauric, myristic and palmitic acids.† Glycerides of caproic and capric acids are present in appreciable quantity; also a trace of stearin and some olein.‡ The fat dissolves readily at a comparatively low temperature in an equal quantity of glacial acetic acid. Such a solution becomes turbid at 40° C.§ By reason of its content of lower fatty acid radicles cocoa-oil has a high saponification value. Cocoa-oil is particularly resistent to the hydrating effect of superheated steam.||

The following data were obtained for the percentage fat-content in the fresh endosperm. The method of determination used was Dormeyer's:¶

	1	2	3	4	5	6	7	Gen'l Average.
Fresh endosperm, *a*.	38.27	40.01	36.71	35.10	34.60	38.90	38.60	
b.	36.14	40.54	35.02	34.90	34.10	40.70	38.40	
Average,	37.20	40.28	35.87	35.00	34.35	39.80	38.50	37.29

The ether extracts containing the oil were free from lecithin

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* Schaedler: Technologie der Fette und Oele des Pflanzen- und Thierrichs, 843. 1892.

† The presence of palmitin (tri) is doubted by Ulzer: Chemisches Centralblatt, II: 1143. 1899.

‡ The so-called "cocinic acid" or "cocostearic acid" derivable from "cocin" or "cocinin" is, like the latter, a mixture. The former is a mixture of some of the above fatty acids; the latter of their glycerides. See Oudemans: Chemisches Centralblatt, 192. 1861.

§ Valenta. Quoted by Vaubel: Physikalischen und chemischen Methoden quantitativen Bestimmung organischer Verbindungen, 1: 162. 1902.

|| Klimont: Journal of the Society of Chemical Industry, 21: 126. 1902.

¶ Dormeyer: Jahresbericht über die Fortschritte der Thier-Chemie, 26: 42. 1896. The fresh tissue was finely divided and weighed, then dried to constant weight at 100–105° C., and all of it extracted with anhydrous sulphuric ether. The usual amounts of tissue were used.

and could be almost entirely saponified. Hammerbacher * in the saponification of 25 grams of the pure oil obtained the following results:

	Grams.	Per Cent
Fatty acids convertible into *insoluble* lead salts,	15.1488	60.595
Fatty acids convertible into *soluble* lead salts,	9.5282	38.113
Glycerin,	0.5596	2.238
Total,	25.2366	100.946

The excess in weight of products is explained by the addition of hydroxyl groups in the cleavage of the triglycerides. König had previously found the glycerin content of cocoa-fat to be 2.08 per cent. Hammerbacher therefore concludes: "It follows from these results that this vegetable fat consists in greatest part of *free* fatty acid."

That there is some error in this conclusion, however, is evident from the results of later work. Benedikt † reports the glycerin content of cocoa-oil to be 13.3–14.5 per cent. Crossley and Le Suer found that the content of *free* fatty acid in terms of oleic acid varied between 2.50 and 8.86 per cent.‡

Stellwaag || studied the fat extracted from cocoa cakes. This oil was rancid, of course. He found the quantity of *free* fatty acid to be only 9.84 per cent. The fat from the ether extract melted at 23° C. The saponification figure was 244.4. The extract contained 81.14 per cent. of neutral fat. The amount of unsaponifiable matter was 0.51 per cent. The molecular weight of the fatty acids was given as 207.¶

Studied through the oleo refractometer of Amagat and Jean, cocoa-oil is found to rotate to the left like an animal fat.**

The composition of cocoa-oil as determined by König †† is:

C.	H.	O.
74.15 per cent.	11.73 per cent.	14.12 per cent.

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* Hammerbacher: Landwirtschaftlichen Versuchs-Stationen, etc., **18**: 472. 1875.

† Benedikt und Zsigmondy: Chemiker Zeitung, **9**: 975. 1885.

‡ Crossley and Le Suer. Quoted by Hopkins: Oil-Chemists' Handbook, 38, table iv. 1900.

|| Stellwaag: Landwirtschaftlichen Versuchs-Stationen, etc., **37**: 135. 1890.

¶ See also König, Menschlichen Nahrungs- und Genussmittel, etc., **2**: 389. 1893.

** Blyth: Foods, Their Composition and Analysis, 359. 1896.

†† König: *loc. cit.*, **2**: 385. See also, Brandes, Pharmaceutisches Centralblatt, 751. 1838.

The following facts regarding cocoa-oil have been compiled from various sources. They may be compared with similar data for other fats and oils given in the standard works of König, Staedeler, Lewkowitsch and others:

A. The heat of combustion of cocoa-oil is 9,066 small calories per gram.* It is as low as that of any other fat; slightly lower than butter. This is due to the fact that it contains a large proportion of fatty acids of low molecular weight.

B. Melting point is at 24° C. Congealing temperature is 22–23° C. Fatty acids from it melt at 24.6° C. They congeal at 19° C.†

C. Saponification value = 257.3–268.4‡

D. Iodine number = 9.0–9.5; same for its fatty acids = 8.5–9.0.§

E. Specific gravity = 0.9115 at 40° C.||

F. Acid value = 9.95–35.21.

G. Reichert-Meissl figure = 7.4; Hehner = 88.6–90.5.

H. Barium figure (König-Hart) = 117–120.

I. Molecular weight of the mixed fatty acids = 196–211.

The use of cocoa-fat and other cheap vegetable oils as a substitute for butter among the poorer classes has been increasing. Cocoa-fat is better adapted for cooking than for table use. It is frequently employed as an adulterant of ordinary butter. Prepared cocoa-fat makes a fairly good substitute for common butter. The fresh material becomes rancid after a time, because of its accumulating content of free fatty acid resulting from bacterial agency. Volatile acids are formed. Its tendency to rancidity is not as great, however, as that of animal fats. The fatty acid present in the fat to begin with can easily be removed with insoluble basic compounds, such as magnesia. By this means

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* Merrill. Quoted by Sherman and Snell: Journal of the American Chemical Society, 23: 166. 1901.

† König: Menschlichen Nahrungs- und Genussmittel, etc., 2: 322. 1893.

‡ König: *Ibid.*

§ Benedikt. Quoted by Vaubel: Physikalischen und chemischen Methoden quantitativen Bestimmung organischer Verbindungen, 2: 235. 1902.

|| Values given after E–I inclusive are quoted by Hopkins: Oil-Chemists' Handbook, 38, table iv. 1900. See also Lane: Journal of the Society of Chemical Industry, 20: 1083. 1901.

a "butter" is made from this oil which has the merit of enduring hot climates without becoming rancid. This product has been recommended for military and naval uses.*

Among the prominent commercial products is the cocoa-butter made in Mannheim, Germany.† König‡ found this product to have the following percentage composition:

Water.	Solids.	Organic Matter.	Inorganic Matter.	Fat.	Fatty Acid.	Nitrogenous Substance.
0.15	99.85	99.848	0.002	99.848	trace.	trace.

It has been stated that cocoa-butter is not very easily digested and that it does not agree with sick people.§ The recent researches of Bourot and Jean,‖ however, show that a specially prepared cocoa-butter melting at 31° C. and containing only a trace of free fatty acid, is quite as easily and completely digested as ordinary butter.¶

We have already alluded to some of the commercial uses to which cocoa-fat is put. Soaps made from it combine with or hold an unusual amount of water while still retaining special hardness, one pound of the oil yielding three pounds of soap.** It is thus well adapted for the preparation of toilet soaps. The soaps made from cocoa-oil are characterized by great solubility in salt solution and can be precipitated from such fluid only by the addition of a very large excess of salt. The so-called "marine" or "salt water soap" has the property of dissolving as well in salt water as in fresh water and is made of cocoa-oil and soda.††

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[*] Rusby: Reference Handbook of the Medical Sciences, 3: 164. 1901.

[†] See Leffman and Beam: Select Methods in Food Analysis, 182. 1901.

[‡] König: Menschlichen Nahrungs- und Genussmittel, etc., 2: 309. 1893. See also Schaedler, Technologie der Fette und Oele des Pflanzen- und Thierreichs, 1340. 1892.

[§] Liebreich: Encyklopaedie der Therapie, 1: 744. 1896.

[‖] Bourot und Jean: Jahresbericht uber die Fortschritte der Their-Chemie, 26: 58. 1896. See also v. Knieriem, Chemisches Centralblatt, 2: 672. 1898.

[¶] "Cocoanut cream," a dietary product much used in the tropics, is made by grating the endosperm and squeezing through cloth the fluid from the finely divided material. In a warm climate the resultant mixture contains much oil and is a very delicious accessory food. Besides the oil, the "cream" contains chiefly carbohydrate and proteid. See page 332 for references to similar fluid obtained from the endosperm by pressure in our own experiments.

[**] Ebermayer: Physiologische Chemie der Pflanzen, 344. 1882. See also Joss, Pharmaceutisches Centralblatt, 449. 1834.

[††] See Schaedler, Technologie der Fette und Oele des Pflanzen- und Therreichs, 1178–1188, 1892, where may be found the results for percentage composition of the sodium soap, given at the bottom of the next page:

The harder fats of the oil make excellent candles. They are used also as constituents for suppositories and related therapeutic products. Medicinally the oil is employed repeatedly as a substitute for lard, olive oil and cod-liver oil. It is also made the chief substance by bulk in various salves and in cold cream, pomade and similar cosmetic preparations. In ointments and cerates it is especially valuable because of its ready absorption when rubbed on the surface of the body; further, it takes up an unusual amount of water—a useful quality when it is desired to apply saline solutions externally. It shows little tendency to produce chemical changes in substances with which it may be associated.

Crude Fiber and Carbohydrates.—Cellulose is a prominent constituent of the endosperm. Associated with the fibrous elements is a polysaccharide, present in comparatively large quantity. This substance is only slightly soluble in water, is insoluble in alcohol, but readily soluble in salt solution. It is precipitated along with globulin when saline extracts of the kernel are dialyzed (page 341). The gum is readily transformed into sugar by the action of diastase or ptyalin.

The fluid pressed from the finely divided endosperm contains a slight amount of reducing sugar—dextrose. Galactose appears to have been identified also.* Cane-sugar is also present.

The following results were obtained in our determinations of the percentage content of crude fiber in the fresh tissue: †

	1	2	3	4	5	General Average.
Fresh endosperm, *a*	3.96	3.20	2.98	3.40	2.78	
b	4.21	3.80	3.12	3.52	2.98	
Average,	4.08	3.50	3.05	3.46	2.88	3.39

Proteids.—That the meat of the cocoanut contains at most only a very small amount of proteid matter is seen at a glance from the following percentage results for content of nitrogen.‡

Water.	Fatty Acid.	Sodium Oxide (combined).	Sodium Oxide (free).	Other Salts.	Residue.
58.74	32.82	4.26	1.50	2.26	0.42

See also the Dispensatory of the United States of America, 1899: 1619, for references to objectionable chemical qualities of some cocoa-soaps.

* Green: Soluble Ferments and Fermentation, 100. 1899.

† Determinations were made, after the fresh weighed material had been dried and thoroughly extracted with ether, by the method adopted by the Association of Official Agricultural Chemists: Bulletin, Division of Chemistry, U. S. Department of Agriculture, 46: 26.

‡ In these determinations the Kjeldahl method was employed.

	1	2	3	4	5	6	7	General Average.
Fresh endosperm, *a*	0.657	0.734	0.806	0.738	0.766	0.776	0.701	
b					0.740	0.781	0.756	
Average,	0.657	0.734	0.806	0.738	0.753	0.778	0.729	0.742

The fresh endosperm contains an average of 0.74 per cent. of nitrogen which, multiplied by the usual factor, 6.25, would indicate 4.63 per cent. of "albuminoid." Some of this nitrogen, however, is undoubtedly closely associated with the fibrous elements. Much of it probably is in the form of nitrogenous extractive.* Some of the nitrogenous substance is soluble in 95 per cent. alcohol.

The proteid present in the endosperm appears to consist chiefly if not exclusively of globulin and proteose (globulose?), the globulin predominating in quantity.† We have made several samples of cocoa globulin by the method used by Osborne for the preparation of edestin—in general as follows:‡ The kernel was run through a hashing machine and the finely minced substance freed from fat by repeated extraction in ether for several days. The ether adherent to the tissue was evaporated at room temperature and the ether-free tissue then extracted in 10-per-cent. salt solution for 24–48 hours. The saline extract was then filtered off and globulin thrown from its solution either by the dilution process, by dialyzing for several days in running water, or by treatment with ammonium sulphate to complete or half-saturation. The deposit of globulin resulting thereby always contained an appreciable amount of gummy carbohydrate. The carbohydrate admixture was eliminated by subjecting the deposit to the action of diastase or ptyalin for 24–48 hours, in the presence of thymol at 45° C. in neutral fluid, during which time it was transformed into soluble reducing sugar.§ The globulin residue left behind after this treatment was further purified by re-solution and re-precipitation. For quantitative analysis some of the final product was washed in water, alcohol and ether, and dried at 100°–105° C. to constant weight.

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* The factor 6.25 is here too large, also, because the proteids present contain about 18 per cent. of nitrogen. See pages 343 and 344. Stutzer found that, of the total nitrogen of cocoa-cakes, from 1.8 to 6.9 per cent. was contained in non-proteid substance. Quoted by Dietrich and König: Zusammensetzung und Verdaulichkeit der Futtermittel; 2: 987, 1380. 1891.

† The amount of nucleoproteid must be very slight.

‡ Osborne: See various papers in the Journal of the American Chemical Society since 1894.

§ Similar difficulty was experienced by Osborne, who got rid of the gum by repeated dialysis and precipitation with ammonium sulphate. Journal of the American Chemical Society, 17: 429, 539. 1895.

Sometimes the globulin prepared in this way was both crystalline and amorphous. At other times it was entirely crystalline. Triangular, hexagonal and rhombohedral forms were frequently seen, although octahedra predominated.* The crystals so closely resemble those we have repeatedly made from hempseed and linseed by the same method, and are so like those given by Osborne for edestin,† that we felt satisfied from the beginning our globulin would prove to be of the edestin type. Careful study of the reactions of the substance convinced us of this fact, for it gives all of those attributed to edestin by Osborne.

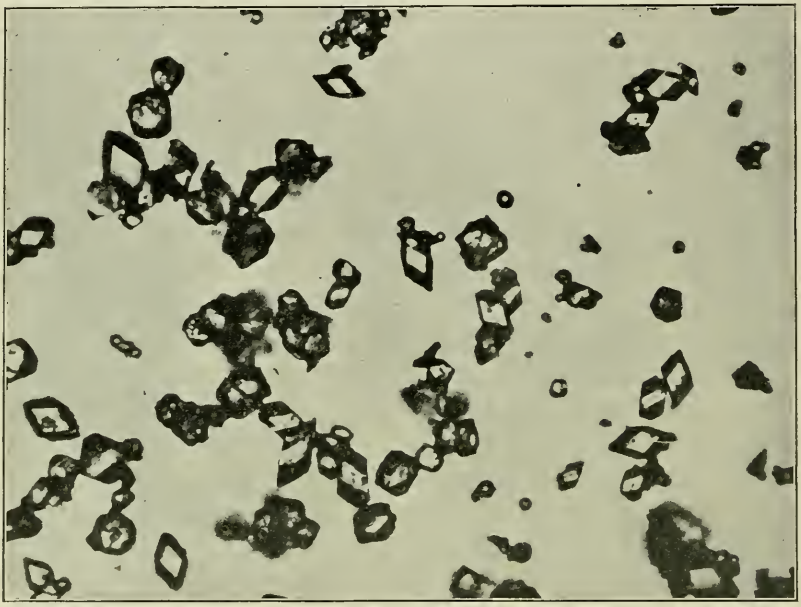

Fig. 4. Crystals of cocoa edestin.

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* The large proportion of gum extracted by the saline solution made it difficult not only to prepare the proteid in pure form but to obtain it quantitatively. Besides, the edestin passed in part into an insoluble modification during the manipulations. An appreciable loss resulted, therefore, in each preparation. We obtained as much as 25 grams of the purified product from the kernels of twelve nuts.

† Osborne: Journal of the American Chemical Society. See also his paper on crystalline vegetable proteids in the American Chemical Journal, 14 : 28. 1893.

On the opposite page we give a microphotographic view of edestin crystals from our second preparation Although not the purest, we have selected this preparation for this purpose because its crystals are mostly rhombohedra. These forms rarely occur in abundance in edestin precipitates, octahedra being more commonly obtained. Most of the larger masses among the crystals shown here are "rounded" octahedra; not in perfect focus because they are thicker than the rhombohedra. The smaller particles consist of globular matter and crystal pieces.

The crystals given in *Fig. 4* were photographed for us by the writer's colleague, Dr. Edward Leaming, who cordially gave us the benefit of his large experience. We wish here again to extend to Dr. Leaming our sincere thanks for his valuable assistance.

That the substance under discussion is edestin is further shown by the results of analysis. We append our results for nitrogen content, as determined by the Kjeldahl method, calculated for ash-free substance:

PERCENTAGE OF NITROGEN IN COCOA EDESTIN

Preparation.	1	2	3	4	5
Analytic results.	17.87 17.77 17.79	17.85 17.96 17.91	17.66 17.69 17.78	18.14 18.21 18.18	18.23 18.20 18.28
Average.	17.81	17.91	17.71	18.18	18.24
Ash.	0.41	0.13	1.12	1.90	1.84

Preparations 1, 2 and 3 contained amorphous material, possibly some of the gummy matter referred to on page 342, in spite of our efforts to completely remove it. Preparations 4 and 5 were obtained from 1 and 3 by further treatment with diastase and by recrystallization by dialysis from 10-per-cent. salt solution. They were practically wholly crystalline.

The above results show that the globulin separated from the cocoanut by the methods here employed is edestin.*

This same proteid of the cocoanut was examined by Ritthausen, † who termed it conglutin without really identifying it with that substance. His analyses gave it a content of nitrogen of 17.87–17.91 per cent. Chittenden and Setchell ‡ referred to it by

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[*] The edestin from barley contains 18.10 per cent. N. That from maize 18.12 per cent.; from rye, 18.19 per cent.; wheat, 18.39 per cent. Osborne: Journal of the American Chemical Society, 17: 547. 1895.

[†] Ritthausen: Jahresbericht über die Fortschritte der Thier-Chemie, 10: 18. 1880.

[‡] Chittenden and Setchell: Quoted by Chittenden, Digestive Proteolysis, 32. 1895.

the name of phytovitellin. The composition they gave for it is in general accord with that of edestin (nitrogen content = 18.40 per cent.), and as they obtained it partly crystallized in octahedra, Osborne * has lately suggested that the substance is edestin. The results we have obtained confirm Osborne's deduction.

The proteose to which we have already alluded was obtained from the globulin filtrate. The latter was freed from traces of globulin by the coagulation method, the hot filtrate evaporated to a small bulk on the water-bath and the proteose precipitated and purified by the usual method. † About four grams were obtainable from fifteen nuts. The product contained both proto and deutero forms. Some heteroproteose was also detected in the products formed on dialysis and a trace of dysprotose was obtained.

The following results for nitrogen content in the ash-free substance were obtained by the Kjeldahl method:

PERCENTAGE OF NITROGEN IN COCOA PROTEOSE

Preparation.	1	2	3	General Average.
Analytic results.	18.67 18.50 18.58	18.48 18.46 18.40	18.57 18.61 18.54	
Average.	18.58	18.45	18.57	18.53
Ash.	1.71	1.08	1.21	1.33

These results differ only slightly from those reported by Chittenden and Setchell.‡ This difference may be explained by the fact that mixtures of proteoses have been analyzed in each case by Chittenden and Setchell, and by us. Their preparation of proteose contained 18.25 per cent. of nitrogen.

In his volume entitled Digestive Proteolysis, Chittenden gives the analytic results for eleven different proteids and the proteoses derived from them (page 67). For seven of these the nitrogen of the corresponding proteose is somewhat higher than that of the original proteid. Analysis of our own preparations has shown the percentage of nitrogen to be greater in the proteose than in the globulin, a result in accord with the majority rule just noted.

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* Osborne: Journal of the American Chemical Society, 18: 13. 1896.

† MacDougal: Practical Text-book of Plant Physiology, 164. 1901.

‡ Chittenden and Setchell: Quoted by Chittenden, Digestive Proteolysis, 32. 1895.

There appeared to be only a very slight amount of an albumin in our extracts—a coagulable substance which was not precipitated from its neutral solution when the latter was half-saturated with ammonium sulphate.*

Osborne's methods of extracting glutenin and gliadin † in dilute alkali and acid, and in dilute alcohol, after the removal of globulin, proteose and albumin as above described, gave mere traces of proteid substances in solution, derivatives, doubtless, of the proteids already referred to, which perhaps had not been completely removed from the residual tissue ; or possible nucleoproteid.

Peptone could not be detected in any of our extracts.‡

Ash.—Composition is referred to on pages 331 and 335. Qualitatively our results were the same as those there given.

Enzymes.—Water, salt solution and glycerin each failed to extract appreciable quantities of either proteolytic or adipolytic enzymes from the endosperm of the fresh, ungerminated nut, although an active amylolytic ferment was extracted by all of these fluids. The large quantities of fat and fatty acid in the endosperm suggest that an emulsifying ferment may be present. This, however, may be localized in the germ, increasing to physiological quantity and activity only in the process of germination (see page 358). The proteoses present in the endosperm seem to imply the presence of a proteolytic ferment. Possibly, however, the proteoses represent a residue from which the globulin was derived by reverse process.§

We have already referred to the fact that oxidase has been detected in the milk. Traces of it are also contained in the endosperm.

Average Composition.—The average results of our analyses of the endosperm are summarized in the following table, which presents the data obtained for the composition of the fresh tissue and the dry solid matter derived from it (constant weight at 100–105° C.).

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* Cohnheim : Chemie der Eiweisskörper, 150. 1900.

† Osborne and Campbell : American Chemical Journal, 15 : 392. 1893.

‡ Small quantities of non-proteid nitrogenous substances were detected by Ritthausen : Chemisches Centralblatt, 230. 1880. Compare, also, with recent results respecting proteoses obtained by Bokorny : Chemisches Centralblatt, 1 : 1167. 1902.

§ See recent papers in the Zeitschrift für physiologische Chemie by Schulze and Kutscher and their associates.

PERCENTAGE COMPOSITION OF THE ENDOSPERM

Constituents.	Fresh Endosperm.	Dry Endosperm.*
Water.	46.31	
Solids.	53.69	
Inorganic matter.	1.03	1.93
Organic matter.	52.66	98.07
Fat (substance soluble in ether).	37.29	69.45
Crude fiber (cellulose).	3.39	6.31
Proteid (N × 5.5)†	4.08	7.60
Soluble carbohydrate, non-nitrogenous substance, extractive, etc. (by difference).	7.90	14.71
Nitrogen.	0.742	1.382

The previous results obtained by Hammerbacher‡ for the fresh endosperm from nuts of eastern origin were as follows:

Water.	Solids.	Inorganic Matter.	Organic Matter.	Fat.	Crude Fiber.	Proteid.	Non-nitrogenous Extractive.
46.64	53.36	0.97	52.39	35.93	2.91	5.49	8.06

COMPOSITION OF SHELL AND HUSK.—We have already alluded to some of the uses to which the shell and husk of the cocoanut are put by reason of the chemical and physical qualities they possess. Some facts regarding their chemical composition were given in the table on page 335.

The following percentage results of elementary analysis of the powdered shell were obtained by Baumhauer;§ all samples having finally been thoroughly extracted in alcohol and ether, and then dried at 120°–150° C.:

	Cocos nucifera.				*Cocos lapidea.*	
	1. Extracted in boiling water.	2. Extracted in boiling water, dilute alkali and acetic acid.	3. Extracted in boiling water, concentrated alkali and acetic acid.	4. Extracted in alkali and in chlorine water.	5. Same treatment as 1.	6. Same treatment as 4.
C.	52.99	47.19	46.27	43.72	52.20	44.20
H.	5.88	6.09	5.81	6.11	5.80	6.24
Ash.	1.43	——	1.00	——	0.22	0.55

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[*] According to Dietrich and König (König, Menschlichen Nahrungs- und Genussmittel, etc., 1 : 612. 1893) the *air-dried* substance contains the following in percentage of the total dry weight:

Total Substance Soluble in Water.	Proteids Soluble in Water.	Sugar (Sugar-Yielding Substance).
15.16	2.27	9.25

[†] The factor 5.5 is used because the proteids of the endosperm contain 18 per cent. of nitrogen. See references in this connection on page 341, footnote.

[‡] Hammerbacher: Landwirtschaftlichen Versuchs-Stationen, etc., 18 : 472. 1875.

[§] Baumhauer: Pharmaceutisches Centralblatt, 601. 1844.

Nitrogen was detected in small amount in the powders which had not been treated with alkali. The alkaline extracts contained substance, precipitable by acetic acid, with the following percentage composition: From *Cocos nucifera*, C = 50.04, H = 5.81, ash = 4.45; from *Cocos lapidea*, C = 52.15, H = 5.93, Ash = 1.00.

Tromp de Haas and Tollens * were able to show the presence of a large amount of pentosane (xylan) in the endocarp, the powdered material yielding an abundance of xylose on hydration in 4 per cent. sulphuric acid. Mannose was absent from the acid solution from which the xylose had been crystallized. After xylan had been completely removed from the shell-powder by the above method, dextrose was derived from the residue on treatment with sulphuric acid in the usual manner.

In his very complete histological studies of the cocoanut, Winton † recently called attention to the fact that both the husk and shell contain a brown substance which is quickly changed to a reddish color by caustic potash, but is unaffected by alcohol, ether or any of the specific reagents for proteids, fats or resins. He also states that no immediate effect is produced by ferric chloride solution, but on long standing the color is changed to olive green. Winton has pointed out the presence of minute silicious bodies among the fibers of the husk.

Winton, Ogden and Mitchell ‡ give the following percentage data for the composition of the shell:

Water,	7.36	Alcohol extract,	1.12
Solids,	92.64	Reducing matters calculated as starch,	20.88
Organic matter,	99.46		
Inorganic matter,	0.54	Starch,	0.73
Soluble in water,	0.50	Crude fiber,	56.19
Insoluble in HCl,	0.00	Nitrogen,	0.18
Ether extract,	0.25	Albuminoid (N × 6 25),	1.13
Non-volatile,	0.25	Quercitannic acid,	1.82
Volatile,	0.00		

During germination the shell remains unaltered. The husk soon begins to decay. See page 351.

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* Tromp de Haas and Tollens: Chemisches Centralblatt, **2**: 359. 1895.

† Winton: American Journal of Science, IV. **12**: 265. 1901. Facts are also given regarding the use of powdered cocoa-shell and the husk as adulterants of ground spices.

‡ Winton, Ogden and Mitchell: Report of the Connecticut Agricultural Experiment Station, **2**: 210. 1898.

COCOANUT PEARLS.—Within the nut there is occasionally found a small stony substance of a bluish white color, a kind of vegetable bezoar, called in India *calappa*, which is eagerly purchased by the Chinese, who ascribe great virtues to it as a sort of amulet to preserve them from diseases. The cause of its formation in the nut is unknown.

According to Harley and Harley * these pearls, like those of molluscan origin, appear to consist almost entirely of calcium carbonate, with water and organic matter in smaller proportion. Riedel, quoted by Harley and Harley, states that in 1886, while in North Celebes, he found a pearl in the endosperm of the cocoanut. One such a pearl was pear-shaped in form and 28 mm. long.

We are greatly indebted to Dr. D. Morris, Imperial Commissioner of Agriculture for the West Indies, for the following very interesting quotation from a letter to Dr. MacDougal :

"More than two hundred years ago Rumph, an eminent botanist in the East, sent as a present to the Grand Duke of Tuscany a ring in which a cocoanut pearl had been set. Further, Rumph himself described cocoanut pearls in his great work with considerable minuteness and gave illustrations of two of them. One was perfectly round, the other was oval or egg-shaped. * * * Travelers in the Philippine Islands have heard of cocoanut pearls, but seldom or ever have seen them. The natives, it is said, keep "cocoanut stones" as charms against disease and evil spirits. The rajahs, we were told, highly prized them and wore them as precious stones. It was only a few years ago that real cocoanut pearls were at last brought to England. One is now at the Museum at the Royal Gardens at Kew, brought by Dr. Hickson. It is almost egg-shaped, perfectly white, and composed almost entirely of carbonate of lime. It has, in fact, a somewhat similar composition to the pearl of the oyster, and yet there is little doubt it is a purely vegetable product." †

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* Harley and Harley: Proceedings of the Royal Society of London, 43: 464. 1887–88.

† "Besides these cocoanut pearls," quoting further from Dr. Morris' letter to Dr. MacDougal, "Rumph describes what he calls 'Melate' pearls taken from the flowers of a Jasmine; and a 'Champake' pearl taken from the flower of a Michelia. If we had not already seen the pearl of the cocoanut it would have been impossible to believe that there were such things as Jasmine and Michelia pearls * * * Of their composition, mode of occurrence and true nature we have yet to learn." See the article by Harley and Harley referred to above.

See also, on the subject of cocoanut pearls, the Proceedings of the Boston Society of Natural History, 1861 and 1862; The Tropical Agriculturalist, 1887; Nature, 1887.

III. CHANGES IN THE COCOANUT DURING GERMINATION

The nuts for our studies of the changes occurring during germination were obtained fresh, fully developed and with their husks still on them, directly from Jamaica. Immediately after their arrival at the New York Botanical Garden they were imbedded in earth until they were nearly covered. The earth was kept saturated with water and a tropical temperature was maintained. These conditions closely approximated those attending normal germination.

MORPHOLOGICAL CHANGES.—Nearly four months elapsed before the shoots began to appear through the husks, the fibers of the husk having been pressed aside in their upward progress. At this stage the stem of the shoot was an inch or more in diameter at the "root-crown," sharply tapering toward the point of penetration at the surface of the husk. As the growth proceeded it seemed to gradually become more and more rapid, and by the end of a year the plants had attained the height of two or three feet, with a stem about an inch in diameter throughout most of its length. By this time the part of the husk under the earth had decayed considerally; it became softer and more porous, and several stout roots had developed through it and penetrated the soil to the depth of a foot or more.*

The appearance of the nuts and their plants at this period of their growth is shown in the cut on page 350. Unless otherwise stated, the chemical analyses reported farther on were made of the parts at this stage of their development.

It may not be amiss, in describing the morphological changes induced in the nut during the process of germination, to also briefly review, at the same time, the more important facts regarding structure of the nut as it exists in the ungerminated condition.

The entire fruit is, strictly speaking, intermediate between a nut and a drupe — a "drupaceous nut." The outer covering,

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* For facts regarding germination and cultivation see Bailey: Cyclopedia of American Horticulture, 1: 341–343. 1900. Also, Wittmack, L.: Die Keimung der Cocosnuss. Ber. d. deut. bot. Ges. 14: 145. 1896.

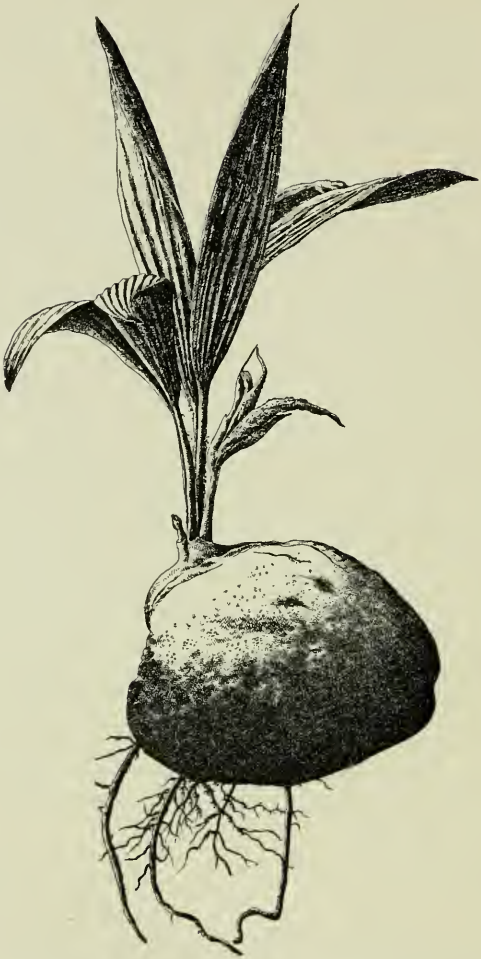

FIG. 5. Germinating cocoanut at the end of a year, showing plumule and roots, with husk little altered except where it was in contact with the earth.

usually removed before the nut appears upon the market, is a thick fibrous layer comprising the exocarp, the epicarp consisting of a smooth, thin, tough coat of a brownish or grayish color. (See pp. 323 and 324). The endocarp, or what is commonly known as the shell of the nut, is composed of three carpels whose lines of fusion are always apparent. The nut lies in the husk with the end containing the "eyes" toward the pedicel. Each carpel contains an "eye," so-called, and under one of these three eyes, the softest, is the germ imbedded in the endosperm. The fertile carpel may be recognized from the fact that it has the greatest degree of divergence between the longitudinal fusion lines of the carpels. The true integuments of the ovule are reduced to a thin brown coat closely adhering to the abundant endosperm.

The embryo is a cylindrical body about 8 mm. in length lying below one of the natural openings of the endocarp and in a line perpendicular to the exterior surface of the endosperm. When germination begins the embryo elongates and, having pushed through its thin coverings, begins to enlarge at both ends. From the outer end arises the plumule and the roots ; the inner end is an extension of the true cotyledon and is developed into a special absorbing organ. See *pl. 19*.

The absorbing organ is of a soft spongy texture and all through it are the ramifications of vascular strands which converge to the narrow " neck, " which connects the absorbing tissue with the stem. The cotyledon, and by this term, hereafter, we shall mean the part of that structure specialized for absorption, can attack only the part of the endosperm to which it is contiguous. In the earlier stages of growth this absorption is confined to the part nearest the young shoot, which we may hereafter refer to as the proximal end of the nut. Finally, however, the cotyledon fills the entire cavity of the nut and somewhat thins the endosperm distally, also.

The milk may persist in the nut until the cotyledon has almost filled the cavity. After germination has proceeded for some time the milk becomes insipid to the taste, and contains fragments of cellulose and large drops of floating fat. In nuts in which germination has continued for a year the cotyledon has entirely filled the cavity, but usually there is still left a third to a half of the endosperm undigested. This residual portion in normal cases is little affected, except that it is softened superficially, and to the taste suggests nothing different from the meat of the ordinary ungerminated nut.

In its natural development the roots of the plant soon take firm hold of the soil and, long before the endosperm is completely absorbed, junction between the shoot and the absorbing organ is broken, the husk decays and the plant enters an independent career. Neither the husk nor the shell appears to serve any other than passive mechanical function, and only the constituents of the endosperm and milk, so far as the nut is concerned, nourish the young plant before it finds in the soil the elements provided there in abundance for its growth to maturity.*

In our microscopic studies, particularly of the cotyledon, pieces of the fresh part were "fixed" in a mixture of glacial acetic acid (⅓) and 70% alcohol (⅔). After remaining in this fluid for a few hours the pieces were transferred to 70% alcohol and later to 85% alcohol, in which they were kept. Sections were cut with a razor and mounted in glycerin. Treated with iodine, such sections of the cotyledon showed an abundance of starch in all cells except those of the outermost layer or epidermis. This outer layer stained yellow with iodine. That it contained an abundance of oil was shown by its deep black reaction with osmic acid. Large globules of oil are, however, distinctly visible in the epidermis under the microscope without the aid of osmic acid. Oil may also be found in the subepidermal layers, but it rapidly diminishes in quantity as the distance from the outside increases and as the starchy deposit accumulates. Needle-like crystals may be very readily found in the epidermal cells. These resemble crystals of tripalmitin, but the fact that so much oil appears in globules, and that the breaking down of fats must occur to a large extent in these cells, would suggest that they are palmitic acid rather than the fat itself.

The above facts make it appear that the starch is formed indirectly at least from the oil.† See references under enzymes, pages 345 and 358.

See *pl. 19* for drawings of parts mentioned above.

CHEMICAL CHANGES.—The following summary gives briefly the effects of germination on the individual nuts examined:

I. *Not Analyzed.*—A. Development had proceeded for nearly six months. The plumule protruded six inches above the husk. Roots had developed through the husk—two were about a quarter of an inch in diameter. The stem was very thick at the "root-crown" ; sharply tapered to the point of surface penetration. The fibers about the stem were tightly pressed together. The neck of the absorbing organ was very woody and fibrous in character. Absorption of the endosperm at the proximal end was quite marked; distal portion undiminished. Milk cavity largely filled by the absorbing organ. A small space at the distal end remained, containing viscid white material full of large oil globules; quantity less than 10 c.c.—doubtless concentrated milk. It was strongly acid in reaction from acid phosphate, reduced Fehling's solution, gave only a faint biuret reaction and was free from starch. The inner surface of the endosperm in the distal portion was soft, having the consistency of lard.

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* Note references on page 357 to the functions of the husk in holding water and possibly furnishing nutrient matter in its decay.

† Ebermayer: Physiologische Chemie der Pflanzen, 347. 1882.

The weight of the whole shoot, minus the roots, in the fresh condition was 28.1 grams. Dry, the weight was 4.25 grams or 15.1 per cent. of the fresh substance, indicating a presence of 84.9 per cent. of water in the original plant.

B. This nut, although germinating for the same period of time, was not quite as far advanced as the previous one, having shoots that were just emerging from the husk. The stem was thicker, however. In most respects its internal condition was exactly the same as that of the first. The fluid in the distal cavity was less in quantity, not as turbid, contained less oil—otherwise was the same as that of the previous nut.

The weight of the entire plumule was 38.8 grams. Dried, it weighed 5.75 grams. Thus it contained 14.8 per cent. of solid matter and 85.2 per cent. of water.

II. *Analyzed.*—1. Growth continued for eight months. The cotyledon entirely filled the cavity. About half of the endosperm was absorbed; practically all of that proximally except a thin layer. The distal residue of endosperm appeared to be normal in taste and appearance except on the surface, where the soft layer previously referred to—one fourth the entire thickness—could again be seen. The outer surface of the cotyledon, that part in contact with the endosperm, was much corrugated; the whole organ, solid but spongy, sweet and agreeable to the taste, pyriform. In the tables on pages 354 and 355 the results of our analyses for this nut are indicated by the numeral 1.

GENERAL COMPOSITION OF THE PARTS OF THE GERMINATED COCOANUT

Parts of the Nut and its Plant.		Percentage of fresh Tissue.				Percentage of Solids.	
		Water.	Solid Matter.			Organic Matter.	Inorganic Matter.
			Total.	Organic.	Inorganic.		
I. *Cotyledon.*							
A. Central, vascular portion :	*a*—1	89.10	10.90	99.14	0.86	92.07	7.93
" " "	*b*—1	87.71	12.29	99.10	0.90	92.25	7.75
" " "	*c*—2	91.62	8.38	99.00	1.00	88.10	11.90
" " "	*d*—2	91.41	8.59	99.11	0.89	89.71	10.29
" " "	*e*—3	88.99	11.01	99.20	0.80	92.77	7.23
Central, between center and surface :	*f*—3	86.07	13.93	98.94	1.06	92.36	7.64
Average.		89.15	10.85	99.08	0.92	91.21	8.79
B. Outer, corrugated portion :	*a*—1	84.95	15.05	98.69	1.31	91.30	8.70
" " "	*b*—2	82.79	17.21	98.93	1.07	93.85	6.15
" " "	*c*—3	80.83	19.17	98.26	1.74	90.93	9.07
Outer portion—neck :	*d*—3	78.98	21.02	98.58	1.42	93.24	6.76
Average.		81.89	18.11	98.62	1.38	92.33	7.67
II. *Residual endosperm.*							
C. Proximal portions after much absorption :	*a*—2	19.09	80.91	99.13	0.87	98.92	1.08
	b—3	23.42	76.58	99.16	0.84	98.90	1.10
Average.		21.25	78.75	99.15	0.85	98.91	1.09
D. Medial portions :	*a*—1	31.65	68.35	99.03	0.97	98.58	1.42
	b—1	30.36	69.64	99.06	0.94	98.65	1.35
	c—2	28.68	71.32	99.25	0.75	98.95	1.05
	d—3	25.77	74.23	99.23	0.77	98.96	1.04
Average.		29.12	70.88	99.14	0.86	98.78	1.22
E. Distal, normal portion :	*a*—3	46.08	53.92	99.02	0.98	98.12	1.82
III. *Stem of the plant.*							
F. Base, "root crown," with petioles at lowest parts :	*a*—1	86.21	13.79	98.95	1.05	92.37	7.63
	b—1	86.51	13.49	98.70	1.30	90.38	9.62
	c—2	85.15	14.85	98.84	1.16	92.06	7.94
	d—3	84.31	15.69	98.68	1.32	91.60	8.40
Average.		85.55	14.45	98.79	1.21	91.60	8.40
G. Parts above the base, with more petioles :	*a*—2	82.47	17.53	98.80	1.20	93.20	6.08
	b—3	79.87	20.13				
Average.		81.17	18.83				
IV. *Petioles.*							
H. Alone, or with young leaves :	*a*—1	83.63	16.37	98.57	1.43	91.27	8.73
	b—1	82 55	17.45	98.63	1.37	92.15	7.85
	c—3	82.13	17.87	98.75	1.25	93.01	6.99
	d—3	82.17	17.83	98.63	1.37	92.34	7.66
Average.		82.62	17.38	98.65	1.35	92.19	7.81

GENERAL COMPOSITION OF THE PARTS OF THE GERMINATED COCOANUT.—*Continued*

Parts of the Nut and its Plant.		Percentage of fresh Tissue.				Percentage of Solids.	
		Water.	Solid Matter.			Organic Matter.	Inorganic Matter.
			Total.	Organic.	Inorganic.		
V. *Leaves.*							
I. Mature or nearly so :	*a*—1	74.66	25.34	98.35	1.65	93.49	6.51
	b—1	71.99	28.01	98.10	1.90	93.20	6.80
	c—2	72.60	27.40	98.34	1.66	93.93	6.07
	d—2	72.51	27.49	98.41	1.59	94.19	5.81
	e—3	68.45	31.55	97.96	2.04	93.52	6.48
	f—3	70.65	29.35	98.39	1.61	94.52	5.48
Average.		71.81	28.19	98.26	1.74	93.81	6.19
J. Very youngest :	*a*—3	87.22	12.78	98.50	1.50	86.67	13.33
VI. *Roots.*							
K. Short, not developed outside of husk, with soft tips :	*a*—1	87.08	12.92	98.46	1.54	88.09	11.91
	b—2	89.89	10.11	98.67	1.33	86.89	13.11
	c—2	86.41	13.59	98.43	1.57	88.44	11.56
	d—3	87.46	12.54	98.83	1.17	90.70	9.30
Average.		87.71	12.29	98.60	1.40	88.53	11.47
L. Parts of longer roots, taken near the stem :	*a*—1	77.92	22.08	98.80	1.20	94.59	5.41
	b—2	82.65	17.35	98.85	1.15	93.34	6.66
	c—3	81.09	18.91	98.50	1.50	92.09	7.91
	d—3	79.47	20.53	98.77	1.23	94.00	6.00
Average.		80.28	19.72	98.73	1.27	93.51	6.49
M. Parts of longer roots, taken outside the husk :	*a*—1	81.70	18.30	97.94	2.06	88.76	11.24
	b—1	84.64	15.36	98.47	1.53	90.05	9.95
	c—2	82.79	17.21	98.40	1.60	90.74	9.26
Average.		83.04	6.96	98.27	1.73	89.85	10.15

2. This nut represented germination after ten months and was essentially like the preceding in all respects. The roots were thicker and a number of good sized ones had not yet proceeded through the husk. Their ends were soft and watery, rounded and blunt. Analyses of this nut are referred to in the tables on pages 354–355 by the numeral 2.

3. Essentially the same as No. 2, both in stage of development and conditions of parts, although the time of germination was about two months longer. Analyses of the parts of this nut are referred to in the tables on pages 354–355 by the numeral 3.

This nut had germinated for just about a year. The following weights of the fresh parts were very carefully taken; the data for nitrogen were determined by the Kjeldahl method.*

	Weight in Grams.	Percentage of Total Weight.	Percentage of Nitrogen.
Cotyledon,	196	28.1	
Central part,			0.14
Cortical layer,			0.31
Endosperm,	155	22.2	
Distal portion,			0.65
Proximal portion,			0.93
Shell,	161	23 0	
Stem,	16	2.3	
Lower part,			0.70
"Root crown,"			0.53
Roots,	41	5.9	
Inside of husk,			0.27
Outside of husk,			0.54
Petioles and young leaves,	58	8.3	0.29
Petioles,			0.39
Old l'aves and petioles,	71	10.2	0.45
TOTAL WEIGHT,	698		
Shell and contents,	512	73.4	
Whole plant,	186	26.6	
Cotyledon and endosperm,	351	50.3	

The tables on pages 354–355 give all our results for general composition of the parts of the germinated nut.† Numerous deductions may be drawn from these results, as to growth and metabolism.

The central part of the cotyledon, with its vascular network, contains more water and less solid matter than any other part of the germinated nut. The proportion of solid substance in it increases toward the corrugated epithelium, being greatest in the "neck," where the structure is fibrous and woody.

That the absorbing organ completely takes up the milk is very evident from the way it fills the cavity and from its own composition, but it is likewise apparent from our results that water is also with-drawn from the residual endosperm, this absorption being greatest at the proximal end of the nut, where absorption was begun in the first place, and least at the distal end, where it had hardly commenced. The roots also are seen to have absorbed considerable moisture.

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* The husk was not weighed because it was decayed underneath and water-logged. Nitrogen was not determined in the shell because its substance remains unaltered during germination.

† The methods of determination were the same as those used previously. The roots, outside of the husk, which had been in the wet soil, were hurriedly rinsed with water to remove inorganic matter then wiped dry with a towel and at once cut into thin cross sections for analysis.

The lowest part of the stem contains almost as little solid matter and is nearly as watery as the cotyledon. The percentage of water in the stem diminishes as the distance away from the " root crown " increases. The watery condition of the lower part of the stem is increased, doubtless, by the fact that the surrounding husk is impregnated with water, thus favoring direct absorption by osmosis and at the same time preventing evaporation from the surface of the growing tissue.

The amount of solid matter in the petioles is also comparatively slight, little more than in the lower part of the stem. In the leaves the water is greatest in the youngest, as would be expected; least in the oldest—those most exposed to the air.

The roots at the tips are soft and watery, but the older they become the more solid matter they develop and the more woody material they accumulate.

In the distribution of the inorganic matter in the fresh parts it is noticeable that the portion of saline substance increases with a decrease of water and *vice versa*, as in the cotyledon, in the residual endosperm and throughout the plumule. This condition is such as might be expected. The relation of the inorganic to the organic matter in each part, however, is variable. The substance of the cotyledon and the stem contains a greater portion of salts than that of the endosperm and the leaves, the roots likewise holding a fairly large amount of saline matter. The substance of the endosperm contains least of all, from which fact it is quite clear that the inorganic matter of the plumule has been absorbed, not only by the cotyledon from the milk, but also by the roots from the fluid in the husk and the surrounding earth.

At the beginning of germination the inorganic matter and water of the milk are doubtless sufficient for the changes that occur, the organic matter coming chiefly from the endosperm. Some time before the cotyledon fills the milk cavity and completely absorbs the milk, the roots have begun to take water and inorganic matter from the fluid in the husk—possibly also organic substance from the disintegrating husk fibers—and thus they absorb new nourishment from a large supply. Growth of the plumule is consequently favored. The plumule soon reaches such a height and development as to enable it to make increasing contributions to the plant metabolism from the gaseous products the air affords. By this time the whole growth has become practically independent of the reserve material of the seed.

ENZYMES.—We made only a few preliminary studies of enzyme distribution. Extracts were made in water, dilute salt solution and glycerin. The indicators used in nearly all the experiments were prepared from the materials in the nut itself.

The extracts of the cotyledon were acid to litmus (phosphates), though, as indicated by lacmoid, they contained no free acid. Diastatic ferment was found to be distributed in abundance in all parts of the cotyledon. Oxidase was also present. Only the very slightest proteolytic action was manifested by the cotyledon extracts, even when they were obtained in particularly concentrated form. In some experiments the results were entirely negative, however. Cellulose-dissolving and fat-splitting enzymes were not detected in either the cotyledon or the residual endosperm, although we cannot be sure that in our few experiments they have not escaped us.* Germination progresses so slowly that possibly some of the enzymes are present in only very minute quantity at any one time—in such amount, perhaps, as to be undiscoverable by the methods commonly employed for ferment detection. We did not examine the parts of the plumule in this connection.

At this point, before we were able to come to any very definite conclusions as to the enzymes present and before we could determine the distribution of proteids, fats, carbohydrates, etc., in the parts of the plant, we were obliged to discontinue our work. The writer hopes to extend these experiments on the germinated cocoanut to a consideration of related problems of nutrition.

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* See our references to enzymes on page 345. Lipase seems to have been found in the germinating cocoanut by Lumia: Jahresbericht über die Fortschritte der Thier-Chemie, **28**: 724. 1898.

Explanation of Plate 19

FIG. 1. An end view of the cocoanut, without its husk, showing the three carpels and the "eyes." The fertile carpel is the one included in the largest angle.

FIG. 2. A sectional view through the end of an ungerminated nut, with its husk removed, showing the form and location of the germ imbedded in the endosperm (under the micropyle). The shell is indicated by the heavy outline.

FIG. 3. Another sectional view similar to that of Fig. 2 showing development of the absorbing organ after germination had proceeded for a few weeks. The incipient stem and roots are to be seen. The cotyledon has enlarged within and without the shell.

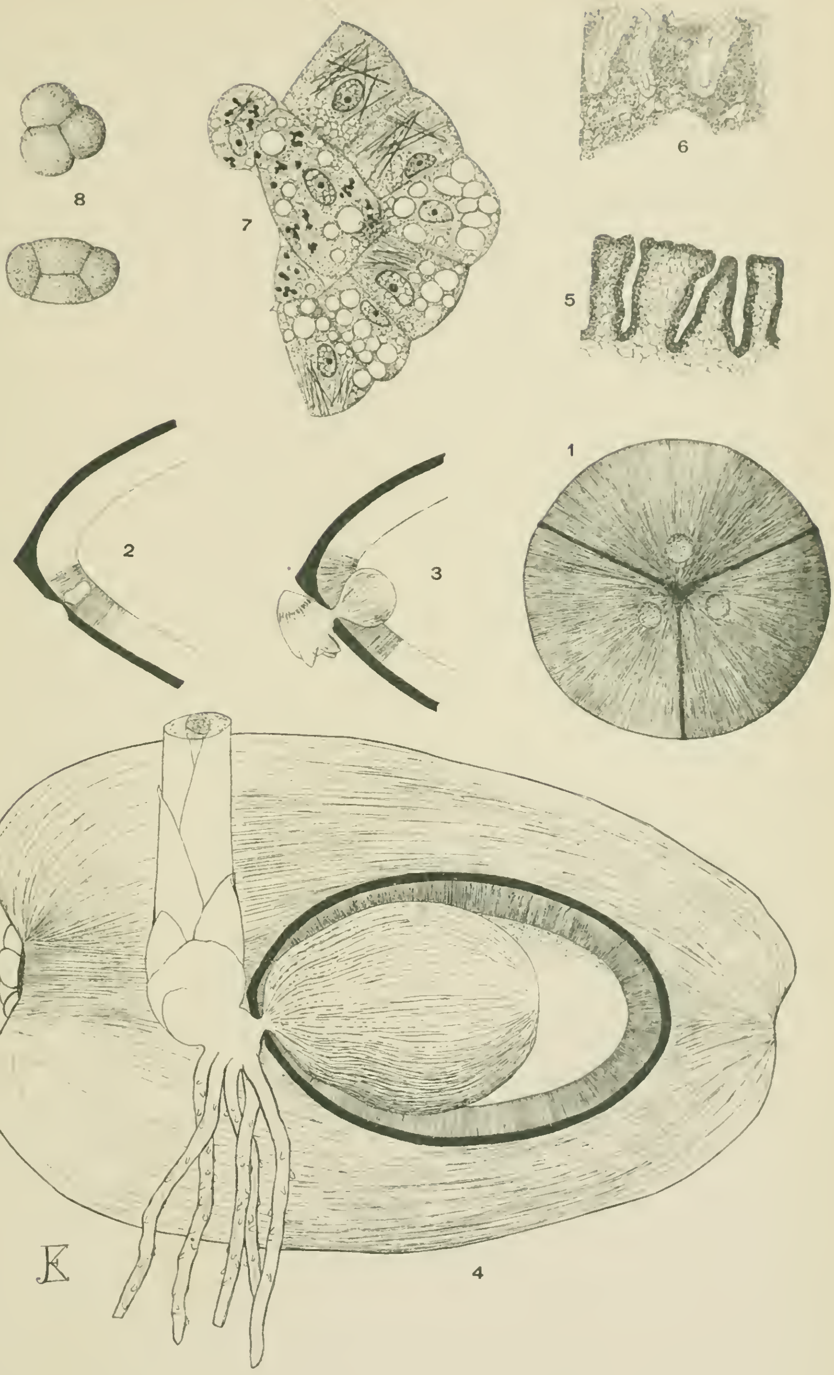
FIG. 4. A longitudinal section through the whole nut somewhat to the side of the median line. It shows the nut imbedded in its fibrous husk and the conditions found after germination had gone on for about five months. The absorbing organ has filled about two-thirds of the cavity of the nut but has absorbed comparatively little of the endosperm. The stem has proceeded upward through the husk, the roots downward through the husk into the soil. The leaves have been cut off above the husk. (See page 350 for appearance of full plumule.)

FIG. 5. A section through the layer of the cotyledon normally in contact with endosperm, showing the corrugated, villiform arrangement of the absorbing epithelium This section having been treated with osmic acid shows the localization of the fat globules.

FIG. 6. A section through that part of the cotyledon given in Fig. 5. This section, treated with iodine, shows the localization of starch.

FIG. 7. A few cells from the absorbing epithelium of the cotyledon after enlargement. This figure shows the large clear oil globules and the darkly staining starch grains in the subepidermal cells. The crystals seen in most of the cells appear to consist of fatty acid, possibly palmitic.

FIG. 8. Enlarged starch granules from subepidermal cells.



COCOS NUCIFERA.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 27

SOME MT. DESERT FUNGI

BY V. S. WHITE.

NEW YORK
1902

[Reprinted from BULLETIN TORREY BOTANICAL CLUB, **29**: *550–563*, 25 September, 1902.]

Some Mt. Desert Fungi

By V. S. White

The country in the neighborhood of Bar Harbor forms a specially interesting collecting ground for the mycologist because of the quantity of wooded land which remains in spite of the constantly increasing clearings and improvements. The woods are moist and kept in this condition even in very dry weather by numerous springs, underground streams and rivulets.

A system of paths originally begun by some of the first Boston visitors, modeled on that in use about the forests of Thüringen near Eisenach is maintained by the Village Improvement Society. The paths extend many miles in various directions ; pocket maps are to be had on which the paths are marked in different colors to correspond with the colors painted upon the trees at short intervals or on occasional signposts ; rude arrows formed by forked white birch branches indicate the entrace to these paths and are also placed at points of intersection, so that there can be no danger of going astray or unnecessarily out of one's way except from heedlessness. These paths though kept free from underbrush and occasionally cleared of dead wood, do not interfere with the natural beauty and wildness of the place and render the task of the collector a far easier and pleasanter one than it would otherwise be. The present list of fungi collected in the vicinity of Bar Harbor, Mount Desert, Maine, from 8 July to 15 September 1901, by the writer have been determined principally by Professor Charles H. Peck. Professor F. S. Earle of the New York Botanical Garden, Professor Underwood of Columbia University, Dr. W. A. Murrill of New York, and Mr. H. J. Banker of California, Pa., have also aided the writer in making determinations. Dried specimens with notes and in some cases water-color sketches have been deposited with the New York Botanical Garden. It is hoped that in the future this list may be greatly enlarged as the fungus flora becomes better known. The present list may serve as a preliminary supplement to Rand's Flora of Mount Desert Island from which the fungi were omitted. The one hundred and twenty species marked with an asterisk (*) are not found in Ricker's List of Maine Fungi (April 1902).

Preliminary List of Bar Harbor Fungi

MYXOMYCETES

ARCYRIA NUTANS (Bull.) Grev.
ARCYRIA INCARNATA Pers.
DICTYDIUM CANCELLATUM (Batsch) Macbr.
FULIGO SEPTICA (Link) Gmel. Common.
LEOCARPUS FRAGILIS (Dicks.) Rost.
LYCOGALA EPIDENDRON (Buxb.) Fr.

ASCOMYCETES

Family HYPOCREACEAE

CORDYCEPS ENTOMORRHIZA (Dicks.) Fr. Only one specimen found.

HYPOCREA RUFA (Pers.) Fr. One form.

HYPOMYCES LACTIFLUORUM (Schw.) Tul. On *Lactarius piperatus*. Plentiful.

NECTRIA EPISPHAERIA (Tode) Fr.

Family CHAETOMIACEAE

*CHAETOMIUM OLIVACEUM C. & E.

Family DIATRYPACEAE

DIATRYPA STIGMA (Hoffm.) De Not.

Family XYLARIACEAE

HYPOXYLON COHAERENS (Pers.) Fr. Common.
HYPOXYLON COCCINEUM Bull. Very plentiful.
XYLARIA POLYMORPHA (Pers.) Fr.

Family MOLLISIACEAE

* MOLLISIA MELALEUCA Fr.

Family HELOTIACEAE

HELOTIUM CITRINUM (Hedw.) Fr.

Family PEZIZACEAE

LACHNEA HEMISPHAERICA Wigg.
LACHNEA SCUTELLATA (L.) Sacc.

DASYSCYPHA AGASSIZII (B. & C.) Sacc. Very plentiful in certain localities.

PEZIZA BADIA Pers. Widely distributed.

Family GEOGLOSSACEAE

GEOGLOSSUM HIRSUTUM Pers. Found only once but growing in large quantities.

LEPTOGLOSSUM LUTEUM (Peck) Sacc. Common on moss-grown decayed stumps.

LEOTIA LUBRICA (Scop.) Pers. Very plentiful in damp woods.

BASIDIOMYCETES

Family PUCCINIACEAE

GYMNOSPORANGIUM CLAVIPES C. & P. On *Juniperus Virginiana.*

Family AURICULARIACEAE

AURICULARIA AURICULA-JUDAE (L.) Schroet. Growing in large quantities in certain localities.

Family TREMELLACEAE

TREMELLODON GELATINOSUM (Scop.) Pers. Plentiful.

Family THELEPHORACEAE

CORTICIUM EFFUSCATUM C. & E.

CORTICIUM INCARNATUM (Pers.) Fr. Plentiful.

CRATERELLUS CORNUCOPIOIDES (L.) Fr. Found only once but in large quantity on hard-packed woody path.

*CRATERELLUS LUTESCENS (Pers.) Fr. Common.

STEREUM HIRSUTUM (Willd.) Pr. Plentiful.

STEREUM OCHRACEOFLAVUM Schwein.

THELEPHORA SCHWEINITZII Peck. Growing in large quantities.

Family CLAVARIACEAE.

CLAVARIA CRISTATA Pers. Common.

*CLAVARIA CIRCINANS Peck. Common.

CLAVARIA FUSIFORMIS Sowerby. Fairly abundant.

CLAVARIA INAEQUALIS Müll.

CLAVARIA PISTILLARIS L. Few specimens found.

Family HYDNACEAE.

* HYDNUM ALBONIGRUM Peck. Found only in one locality.

* **Hydnum boreale** Banker, sp. nov. Plant white to greenish, moist; pileus thick, convex, undulate, 12–15 cm. wide; stem short, thick, flattened, the longer diameter three times the shortest (2 cm. by 7 cm.), 7 cm. long; teeth short, 5 mm. long, 0.5 mm. wide, the points rounded and somewhat knobbed when dry, decurrent, brownish with white tips; substance zonate within, the uppermost layer white spongy thick, the lower strata becoming darker, harder, and more compact, in the stem deep lavender color; mycelium purple, persistent; odor unpleasant.

In damp rich soil and leaf mould.

HYDNUM CARBUNCULUS Secr. (= *H. ferrugineum* Fr.) The peppery taste of this species has not been previously noted and is an important character.

* **Hydnum humidum** Banker, sp. nov. Plant yellowish, becoming brown, hygrophanous, pileus irregular, spongy, scrobiculate, 9 cm. or more wide, stem stout, brownish, about 2 cm. long, 1.5 cm. thick; teeth long, 5 mm., brownish with white tips; substance corky, hard when dry and gray like weathered wood but with streaks and spots that appear darker and cartilaginous, which cut as if gummy, zonate internally; odor strong but not unpleasant; taste mild.

In hard-packed wooded path. The fresh plant exudes water freely when pressed between the fingers.

HYDNUM REPANDUM L. Fairly common.

* HYDNUM SCROBICULATUM Fr.

HYDNUM ZONATUM Batch.

Family POLYPORACEAE.

DAEDALEA CONFRAGOSA POLYPOROIDEA Peck. Plentiful.

FAVOLUS ALVEOLARIUS (DC.) Quel. Fairly abundant.

POLYPORUS ADUSTUS (Willd.) Fr.

* POLYPORUS CARPINEUS Sower.

POLYPORUS CARNEUS Nees.

POLYPORUS CHIONEUS Fr.

POLYPORUS CONNATUS Wein.

* POLYPORUS CONFLUENS (A. & S.) Fr. Plentiful.

POLYPORUS ELEGANS (Bull.) Fr. Fairly abundant.

POLYPORUS FOMENTARIUS (L.) Fr.

Polyporus leucophaeus Mont.

Polyporus perennis (L.) Fr.

Polyporus picipes Fr.

Polyporus pergamenus Fr. Very common.

Polyporus Schweinitzii Fr. Plentiful.

Polyporus Schweinitzii dualis Peck.

Polyporus splendens Peck. (*P. oblectans* of Ricker's list, but that species is not likely American.)

Polyporus sulfureus (Bull.) Fr.

Polyporus versicolor (L.) Fr. Very common in all localities.

Polyporus vaporarius Fr.

Lenzites sepiaria Fr.

Trametes cinnabarina (Jacq.) Fr.

* Trametes rubescens Fr.

Family Boletaceae

Boletinus pictus Peck. Common in damp places, *Sphagnum*, etc.

* Boletus albus Peck. Only one plant seen.

Boletus Americanus Peck. Common in damp places.

Boletus chromapes Frost. Fairly common but scattered, rarely more than one plant in a locality.

* Boletus cyanescens Bull. Common.

* Boletus edulis Bull. Plentiful.

* Boletus edulis clavipes Peck. Common.

* Boletus felleus Bull. Rather scarce.

Boletus granulatus albipes Peck. Plentiful.

* Boletus miniato-olivaceus sensibilis Peck. Common.

* Boletus ornatipes Peck. Very common in woods.

* Boletus piperatus Bull. Common in woods and by roadsides.

* Boletus purpureus **fumosus** Peck, var. nov. Pileus convex, velvety, smoky brown, flesh creamy-yellow, changing to bluish-green where wounded; tubes depressed about the stem, yellowish-green, the mouths small, brownish-red, the dissepiments slightly decurrent on the stem, changing to greenish-blue where wounded; stem tapering upward, yellow above, colored like the pileus below, bright yellow within, changing to bluish-green where wounded; spores 10 μ long, 5 μ broad.

Pileus 4–14 cm. broad; stem 4–12 cm. long, 1–2.5 cm. thick at the top, 2.5–5 cm. thick at the base.

Woods. July.

This *Boletus* agrees so closely with *B. purpureus* in all its characters except color that it has seemed best to consider it a mere variety of that species, but future investigation may show it to be a distinct species. It does not appear to have any purple hues in either pileus or stem.

* BOLETUS RUSSELLII Frost. Under pines in dry soil; scarce.

BOLETUS SCABER Frost. Very common and variable.

* BOLETUS SCABER MUTABILIS Peck. Common.

* BOLETUS SCABER NIVEUS Peck. Common.

* **Boletus scabripes** Peck, sp. nov. Pileus thick, broadly convex, firm, dry, glabrous, reddish-brown with a bloom; tubes convex in the mass, adnate or slightly depressed around the stem, brown, with very small round darker mouths; stem stout, equal, solid but spongy within, grayish-white, adorned with numerous small projecting black points; spores oblong, fusiform, 12–15 μ long, 4–5 μ broad.

Pileus about 15 cm. broad; stem about 10 cm. long, 2–3 cm. thick.

Rich soil in woods. July. A fine large species but with a disagreeable taste. The black points on the stem are suggestive of those on the stem of *B. scaber*, but they are smaller and more numerous. In drying the plants become black and exude a black juice with a strong odor.

* BOLETUS SUBGLABRIPES Peck. In damp shady soil; only two plants found.

BOLETUS SUBLUTEUS Peck. Very plentiful all summer.

Family AGARICACEAE

(*Cantharelleae*)

CANTHARELLUS AURANTIACUS (Wulf.) Fr. Plentiful.

CANTHARELLUS CIBARIUS Fries. Common and widely distributed.

* CANTHARELLUS FLAVICEPS Peck.

CANTHARELLUS FLOCCOSUS Schwein. Very plentiful in a few localities.

CANTHARELLUS MULTIPLEX Underw. Two specimens. Specimens attaining a large size, some measuring nearly 17 cm. across.

TROGIA CRISPA (Pers.) Fr. Plentiful in a few localities.

(*Paxilleae*)

* PAXILLUS ATROTOMENTOSUS Fr. Found plentifully in one locality; a very showy fungus.

* PAXILLUS INVOLUTUS (Batsch.) Fr. Plentiful.

* PHELLOPORUS RHODOXANTHUS (Schwein.) Peck. Only two plants found; in widely different localities.

(*Coprineae*)

* COPRINUS ATRAMENTARIUS (Bull.) Fr. Plentiful.

COPRINUS ATRAMENTARIUS SILVESTRIS Peck. Found only in one locality but abundant there.

* COPRINUS PLUMBEUS Peck. A large quantity in damp weather.

(*Hygrophoreae*)

HYGROPHORUS CANTHARELLUS Schwein. Fairly common.

* HYGROPHORUS CHLOROPHANUS Fr. Abundant in restricted localities.

* HYGROPHORUS COCCINEUS Schaeff. In large quantities in damp weather.

HYGROPHORUS CONICUS (Scop.) Fr. Abundant.

HYGROPHORUS MINIATUS Fr. Found once or twice only.

* NYCTALIS ASTEROPHORA Fr. Growing on much-decayed specimens of *Russula* and *Lactarius piperatus*. This is a very strange species, in which the lamellae are almost entirely undeveloped and the entire top of the fungus bears the spores.

(*Lactarieae*)

LACTARIUS AFFINIS Peck. Pale form; plentiful.

LACTARIUS CINEREUS Peck. Only two or three plants found.

LACTARIUS DECEPTIVUS Peck. Plentiful.

LACTARIUS DELICIOSUS (L.) Fr. Fairly common in certain localities.

* LACTARIUS FULIGINOSUS Fr. Plentiful.

LACTARIUS GRISEUS Peck. Plentiful in damp woods.

LACTARIUS HYSGINUS Fr. Plentiful in damp woods.

LACTARIUS INSULSUS Fr. Only one plant seen.

* LACTARIUS MACULATUS Peck. Only two specimens found; a showy plant.

* LACTARIUS PIPERATUS (Scop.) Fr. Common.

* LACTARIUS SORDIDUS Peck. Found only once but then in large quantities.

LACTARIUS SUBDULCIS (Bull.) Fr. Plentiful and widely distributed.

* LACTARIUS TORMINOSUS (Schaeff.) Fr. Found twice.

LACTARIUS THEIOGALUS (Bull.) Fr. Found in only one locality growing in leaf mould.

LACTARIUS UVIDUS Fr. Only a few plants found, some growing on wood.

LACTARIUS VOLEMUS Fr. Common.

* RUSSULA ADUSTA (Pers.) Fr. Common.

* RUSSULA BREVIPES Peck. Plentiful.

* RUSSULA BASIFURCATA Peck. Found several times.

RUSSULA DECOLORANS Fr. Plentiful and widely distributed.

* RUSSULA EMETICA Fr. Common.

* RUSSULA FINGIBILIS Britz. Only found three times.

RUSSULA FOETENS (Pers.) Fr. Common.

* RUSSULA FRAGILIS (Pers.) Fr. Only a few plants found.

RUSSULA INTEGRA (L.) Fr. Plentiful.

* RUSSULA LUTEA (Huds.) Fr. Found only one.

* RUSSULA MARIAE Peck. Fairly widely distributed.

* RUSSULA NIGRICANS (Bull.) Fr. Found abundantly in a few localities.

* RUSSULA PULCHRALIS Britz. Plentiful in one locality.

* RUSSULA PALUSTRIS Peck. By roadside; found several times.

RUSSULA PURPURINA A. & S. White-stemmed form; found only once but in large quantities.

* RUSSULA PUELLARIS UMBONATA Peck. Only one plant found.

* RUSSULA ROSACEA Fr. Abundant.

* RUSSULA SCABRIUSCULA Peck. Apparently scarce.

* RUSSULA SORDIDA Peck. Plentiful.

(*Marasmieae*)

LENTINUS LEPIDEUS Fr.

MARASMIUS ANDROSACEUS (L.) Fr. On hemlock needles after rain in large quantities.

* MARASMIUS CONFLUENS Pers.

MARASMIUS OREADES Fr. Forming large nearly complete fairy rings.

MARASMIUS ROTULA (Scop.) Fr. Plentiful.

* MARASMIUS VITICOLA B. & C. Plentiful.

PANUS STYPTICUS (Bull.) Fr. Common.

(*Agariceae*)

(*Evelatae.* With neither volva nor annulus)

* CLITOCYBE ECTYPOIDES Peck. Plentiful on damp banks.

* CLITOCYBE INFUNDIBULIFORMIS Schaeff. Common.

CLITOCYBE LACCATA Scop. Common.

* **Clitocybe marginata** Peck, sp. nov. Pileus fleshy, rather thick, subcampanulate, becoming convex, obtuse or broadly umbonate, glabrous or nearly so, dry, bay red verging to mahogany color, the margin at first involute, flesh yellow; lamellae narrow, close, decurrent, yellowish, reddish on the edge; stem nearly equal, stout, hollow, glabrous, shining, yellowish marked with reddish longitudinal lines; spores subglobose, 5 μ long, 4–5 μ broad. Pileus 5–8 cm. broad; stem 5–8 cm. long, 6–12 mm. thick. Cespitose; growing around decaying stumps. September.

A peculiar species well marked by the reddish edge of the lamellae, reddish lines of the stem and yellowish flesh of the pileus. It is referable to the second subsection of the Disciformes according to arrangement in *Sylloge Fungorum.*

CLITOPILUS CAESPITOSUS Peck. Found only once but in large quantities.

* CLITOPILUS CARNEOALBUS With. Fairly abundant in certain localities.

* CLITOPILUS PRUNULUS Scop. Very common in meadows.

COLLYBIA ABUNDANS Peck. Growing in large clusters.

* COLLYBIA COLOREA Peck. Growing in large quantities, singly and in clusters.

COLLYBIA DRYOPHILA Bull. Common.

* COLLYBIA FAMILIA Peck. Growing in great quantities over old decaying stumps.

* COLLYBIA PLATYPHYLLA Fr. Common.

COLLYBIA RADICATA Relh. Common and variable.

* COLLYBIA RADICATA FURFURACEA Peck. Found only once; seven or eight fine plants growing about a much-decayed stump.

CREPIDOTUS APPLANATUS Pers. Common.

* CREPIDOTUS MALACHIUS B. & C.

CREPIDOTUS VERSUTUS Peck.

* ENTOLOMA CUSPIDATUM Peck. Growing in large quantities.

ENTOLOMA GRAYANUM Peck. Only a few plants seen.

* ENTOLOMA PECKII Burt. Plentiful.

* ENTOLOMA SALMONEUM Peck. Plentiful.

* ENTOLOMA SINUATUM Fr. One cluster of five specimens found; a fine large species.

* LEPTONIA ASPRELLA Fr. Short-stemmed form; fairly common.

* LEPTONIA GRISEA Peck. Four or five plants found.

* LEPTONIA FORMOSA Fr. Fairly common.

* LEPTONIA SERRULATA (Pers.) Fr. A beautiful species which appears to be rare.

* LEPTONIA SUBSERRULATA Peck. A few specimens found in grass two hundred feet from the beach.

MYCENA CORTICOLA Schum. A beautiful little fungus 2 cm. high, growing on wood; only occasionally seen.

* MYCENA HAEMATOPODA Pers. Plentiful in certain localities.

* NOLANEA CONICA Peck. Appears to be scarce; growing on wood.

OMPHALIA CAMPANELLA Batsch. Growing as usual in large quantities on decaying wood.

* OMPHALIA SCABRIUSCULA Peck. Plentiful.

PANAEOLUS CAMPANULATUS (L.) Sacc.

* PANAEOLUS FIMICOLA Fr. Common after rains.

* PLEUROTUS OSTREATUS (Jacq.) Fr. Plentiful, growing in dense clusters.

* PLUTEUS CERVINUS Schaeff. Very common and variable; a white variety found and also a scaly one corresponding to *Agaricus rigens* Pers.

* PLUTEUS GRANULARIS Peck. Only one plant found.

* PLUTEUS UMBROSUS Pers. Found twice on decaying wood.

* TRICHOLOMA ALBOFLAVIDUM Peck. Plentiful.

TRICHOLOMA ALBUM (Schaeff.) Fr. Growing singly in leaf mould.

TRICHOLOMA DAVISIAE Peck. Plentiful.

* TRICHOLOMA FALLAX Peck. On dead leaves and twigs after rain.

* TRICHOLOMA FUMOSOLUTEUM Peck. Abundant.

* TRICHOLOMA LUGUBRE Peck. Plentiful.

* TRICHOLOMA RUTILANS Schaeff. Appears to be rare.

* TRICHOLOMA VARIEGATUM Scop. Found only twice; a pretty species.

(*Velatae.* Provided with a veil, but no volva)

CORTINARIUS ARMILLATUS (A. & S.) Fr. Fairly abundant.

* CORTINARIUS BERLESIANUS Sacc. & Cub. Only two plants found.

* CORTINARIUS CORRUGATUS Peck. Found twice but in large quantities.

* CORTINARIUS ERRATICUS Peck. Plentiful; growing in large semicircles in damp leaf mould.

* CORTINARIUS MULTIFORMIS Fr. Plentiful.

* CORTINARIUS SIMILARIS Peck. Two plants seen.

CORTINARIUS TORVUS Fr. Plentiful in one locality.

CORTINARIUS VIOLACEUS (L.) Fr. Abundant.

* **Cortinarius Whiteae** Peck, sp. nov. Pileus fleshy, hemispherical, becoming nearly plane with a lobed wavy or irregular margin, dry, glabrous, subpruinose, reddish or brownish-orange verging to tawny; lamellae subdistant, deeply and broadly emarginate, reddish-brown becoming brownish-cinnamon; stem long, equal, solid, fibrous, colored like the pileus, adorned with darker fibrous lines or striations; spores subglobose, 7–8 μ long, 7 μ broad.

Pileus 6–12 cm. broad; stem 7–12 cm. long, 1.5–2 cm. thick.

Woods. August. A large species intermediate between *Dermocybe* and *Telamonia*, related to the former by its dry pileus and to the latter by its general aspect and stout solid stem. It gives me pleasure to dedicate it to its discoverer, a most enthusiastic mycologist from whose specimens, notes, and colored sketch of the fresh plant the description has been derived.

Flammula flavida Pers. On fallen spruce in large quantities.

* **Flammula granulosa** Peck, sp. nov. Pileus thin, hemispherical, becoming convex, dry, densely squamulose, tawny; lamellae thin, rather broad, subdistant, adnate or slightly decurrent, pale yellow becoming tawny ferruginous; stem fleshy, rather slender, stuffed, glabrous or sometimes minutely squamulose, colored like the pileus; spores elliptic, generally uninucleate, 7–8 μ long, 4–5 μ broad.

Pileus 1.5–3 cm. broad; stem 2.5–3 cm. long, 1.5–3 mm. thick.

Decaying wood. August. This is a small species but easily recognized by the squamules of the pileus which give to its surface a granular appearance similar to that of the pileus of *Lepiota granulosa*. At the base of the stem there is a colored membranous disk by which the plant is attached to its place of growth.

* Flammula sapinea Fr. Appears to be scarce.

Flammula spumosa Fr. Plentiful.

* Hypholoma capnoides Fr. Found only once; growing singly and in clusters.

* Hypholoma hydrophilum (Bull.) Sacc. A single cluster of five or six found in a hollow at foot of maple in decaying wood and leaf mould; spores a rich purple red.

Hypholoma incertum Peck. Plentiful in paths singly or in clusters.

* Hypholoma perplexum Peck. Plentiful.

* Inocybe rimosa (Bull.) Fr. Two plants found in deep leaf mould in woods.

* Naucoria erinacea Fr. Only a few plants found.

Naucoria semiorbicularis Bull. Large quantities found in lawn.

* Tubaria furfuracea Pers. A few specimens found in decaying leaves in damp woods; a pretty little species.

(*Annulatae.* Provided with a veil which remains as a permanent annulus; no volva)

* Agaricus abruptus Peck. Many very large specimens found.

AGARICUS CAMPESTRIS L. Abundant in certain localities.

ARMILLARIA MELLEA Vahl. Only one cluster found, which is unusual for this species.

* LEPIOTA ILLINITA Fr. Found in only two localities.

* LEPIOTA NAUCINOIDES Peck. A single plant found in lawn.

* PHOLIOTA AGERICOLA Peck. Only two plants found.

* PHOLIOTA CAPERATA Pers. Plentiful.

* PHOLIOTA CERASINA Peck. In large clusters on decaying spruce.

* PHOLIOTA SQUARROSOIDES Peck. Growing in large clusters; plentiful in certain localities.

STROPHARIA HOWEANA Peck. Only a few plants found in rich woods in leaf mould.

STROPHARIA SEMIGLOBATA Batsch. Common in lawns.

* STROPHARIA STERCOREA Fr. Abundant after rain.

(*Volvatae.* Provided with a volva; usually also
with a veil and annulus)

* AMANITA CRENULATA Peck. Only a few specimens found.

* AMANITA FLOCCOCEPHALA Atk. Three or four plants seen.

AMANITA FROSTIANA Peck. Abundant.

*AMANITA MAPPA Fr. Growing singly in rich soil.

AMANITA MUSCARIA (L.) Fr. Abundant.

*AMANITA MUSCARIA FORMOSA Gonn. & Rab. Fairly common.

AMANITA PHALLOIDES Fr. Abundant.

*AMANITA RUBESCENS Fr. Abundant.

AMANITA SPRETA Peck. Rare.

*AMANITA VERNA Fr. Fairly common.

*AMANITOPSIS VAGINATA (Bull.) Roz. A white variety also found.

*AMANITOPSIS VAGINATA FULVA (Schaeff.). Common.

*AMANITOPSIS VAGINATA **crassivolvata** Peck, var. nov. Pileus broadly convex or nearly plane in the mature plant, subumbonate, glabrous, viscid when moist, widely sulcate striate on the margin, creamy yellow; lamellae broad, close, free, white, sometimes tinged with yellow; stem long, equal, hollow or stuffed with cottony fibers, colored like but a little darker than the pileus, volva very thick, loose, white and woolly; spores globose, 8–10 μ broad. Pileus 7–10 cm. broad; stem 15–20 cm. long, about 2 cm. thick.

In damp soil. Although the sheathed *Amanitopsis* is a very variable species, this large form is so well marked by the very thick felty volva that it seems best to separate it as a variety. It does not closely sheath the base of the stem as in the common form but spreads away above and assumes the shape of a wine glass or goblet.

* AMANITOPSIS VOLVATA (Peck) Sacc. Growing singly; three specimens found.

Family SCLERODERMATACEAE

SCLERODERMA VULGARE Hormen. Appears to be rare.

* SCLERODERMA VERRUCOSUM (Pers.) Bull.

Family LYCOPERDACEAE

BOVISTA PILA B. & C. Common in fields.

BOVISTA PLUMBEA Pers. Common in sandy ground near the ocean.

* GEASTER FORNICATUS (Huds.) Fr. Found in one locality only.

* LYCOPERDON ATROPURPUREUM Vitt.

LYCOPERDON GEMMATUM Batsch. Common.

* LYCOPERDON PECKII MORG.

LYCOPERDON PYRIFORME Schaeff. Common.

LYCOPERDON SEPARANS Peck.

LYCOPERDON SUBINCARNATUM Peck.

LYCOPERDON TURNERI E. & E.

Family PHALLACEAE

* DICTYOPHORA DUPLICATA (Bosc.) E. Fisch. Plentiful in woods in one locality.

* MUTINUS CANINUS (Huds.) Fr. A few specimens only found.

NEW YORK, N. Y., July 1902.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 28

FOSSIL FERNS FROM THE LARAMIE GROUP OF COLORADO.

By ARTHUR HOLLICK.

NEW YORK
1902

[Reprinted from TORREYA, Vol. 2, No. 10, October, 1902.]

FOSSIL FERNS FROM THE LARAMIE GROUP OF COLORADO.*

By Arthur Hollick

(Plates 3 and 4)

Some twelve or thirteen years ago an extensive collection of fossil plants, from the Laramie (Upper Cretaceous) Group of Colorado, was made by Messrs. George Hadden and R. C. Hills, for the late Dr. J. S. Newberry. This collection is now in the paleobotanical museum of the New York Botanical Garden, and, although partly labeled, was never reported upon by Dr. Newberry.

Included in the collection are a few ferns, most of which are more or less rare and some of them apparently represent undescribed species or varieties. Of these the following have been selected as noteworthy:

Anemia supercretacea sp. nov.

General form of frond, also nervation, unknown; pinnae delicate, narrowly conical in outline, gradually tapering to the tips; pinnules entire, lower ones spatulate, distinct, somewhat decurrent along and forming acute angles with the rachis, upper ones often more pointed or becoming confluent and forming toothed or crenulated tips to the pinnae. Plate 3, Figs. 6, 7.

In reddish shaly sandstone, Florence, Colo.

Anemia robusta sp. nov.

General form of frond, also nervation, unknown; pinnae (?) linear in outline, about 3 cm. in width; pinnules entire, ovate to subspatulate, with blunt wedge-shaped tips, about 2.5 cm. in length by 12 mm. in width, more or less confluent or decurrent along the rachis, each one provided with a weak midvein. Plate 3, Fig. 1.

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* Read before the Botanical Society of America, Pittsburg Meeting, July 1, 1902

In grayish sandstone, Florence, Colo.

ASPLENIUM MAGNUM Knowlton, Monog. U. S. Geol. Surv. **32**: 667. *pl. 79. f. 5–8a*

I have figured these specimens for the reason that they show some slight differences or variations from the type figured by Knowlton. In ours the pinnae are more deeply dissected, so that the pinnules are more distinctly separated and are merely confluent close to the rachis. They are also somewhat more pointed and falcate in outline. Plate 4, Figs. 1, 2.

In general appearance they both resemble *Aspidium Kennerleyi* Newb. (Boston Jour. Nat. Hist. **7**: 513. 1863; Monog. U. S. Geol. Surv. **35**: 11. *pl. 16. f. 4, 5.* 1898), which differs chiefly in the pinnules, for the most part, being finely denticulate near their extremities, although "sometimes entire," according to the description.

Fig. 1 in reddish shaly sandstone, Fig. 2 in black carbonaceous shale, Florence, Colo.

Acrostichum Haddeni sp. nov.

General form of frond unknown; pinnae (?) apparently 20 cm. or more in length by about 3 cm. in maximum width, narrowed to acute tips and with coarsely crenulate-serrate margins; nervation consisting of a series of alternate pinnately arrranged veins, extending from the rachis to the extremities of the serrations, with the spaces between occupied by a network of fine nerves. Plate 4, Figs. 3–6.

Named for Mr. George Hadden, the collector.

Figs. 3, 5 and 6 in grayish sandstone, Walsenberg Colo.; Fig. 4 in gray shale, Florence, Colo.

Polystichum Hillsianum sp. nov.

General form of frond unknown; pinnae (?) linear-oblong in outline, about 3 cm. in maximum width, narrowed to 18 mm. at the base, deeply pinnatifid; pinnules entire, linear to subfalcate in outline, blunt-pointed or obtuse at apex, alternately disposed and confluent along the rachis; nervation pinnate, consisting of a series of primary nerves extending from the rachis to the extremities of the pinnules and numerous secondary nerves, once forked. Plate 4, Fig. 7.

Named for Mr. R. C. Hills, largely through whose efforts the collection was acquired.

In reddish shaly sandstone, Florence, Colo.

Gleichenia rhombifolia sp. nov.

General form of frond, also nervation, unknown; pinnae linear in outline, acute, about 5 mm. in width, composed of subquadrate pinnules, the lower ones distinct, acute and curved inward at the tips, the upper ones becoming confluent or closely approximated and all of nearly uniform length, giving to the pinnae a delicate, ribbon-like appearance. Plate 3, Fig. 3.

In reddish shaly sandstone, Florence, Colo.

GLEICHENIA DELICATULA Heer (?), Fl. Foss. Arct. 3^2: 54. *pl. 9. f. 11c; pl. 10. f. 16, 17*

This specimen agrees quite satisfactorily with Heer's Fig. 11c above quoted, but not so closely with his other figures, which show pinnae broader at their bases and not so uniform in width throughout as in ours. Further than this, if we determine these to be identical this determination would infer a very extensive vertical range for the species, a range which we would hardly be justified in assuming without question, upon such meager evidence as that afforded by the single fragment represented by our specimen, although there would be no inconsistency in identifying a species from the Kome beds with one from the Laramie. Plate 3, Fig. 4.

In reddish shaly sandstone, Florence, Colo.

PECOPTERIS (CHEILANTHES) SEPULTA Newb. (?) Monog. U. S. Geol. Surv. **35**: 12. *pl. 62. f. 5, 5a, 6.* 1898

Pecopteris (*Phegopteris*) *sepulta* Newb. Proc. U. S. Nat. Mus. **5**: 506. 1883.

After some hesitation I have finally decided to refer our specimen provisionally to this species. The differences are slight and the resemblance is so close that a distinction seems hardly to be warranted. Plate 3, Figs. 5, 5a.

Newberry's figures show the pinnae at the extremity of the frond to be either entire or wavy-margined and confluent along the rachis, while lower down they are subdivided into more or less distinct pinnules and are apparently separated from each other, although the basal pinnules are attached to the rachis.

The only difference on the part of our specimen is that the basal pinnules are free; but this may be and probably is due to its representing a yet lower portion of a frond than is depicted in either of Newberry's figures, which in themselves indicate a transition to a base similar to ours.

The reference to the Paleozoic genus *Pecopteris* will doubtless be criticised on general principles, but rather than add to the synonymy I have thought it best to adhere to the name last used by Dr. Newberry.

In grayish sandstone, Walsenberg (?),[*] Colo.

Stenopteris (?) **cretacea** sp. nov.

General form of frond unknown, but apparently large and strong; each pinna or branch consisting of a broad-winged rachis, with relatively remote, entire, strap-shaped pinnules, each of which is traversed by a strong midvein from base to apex; secondary nervation unknown.

The fragmentary nature of our specimen renders accurate comparison difficult and it is possible that it might equally well be considered under the genus *Thaumatopteris*, hence the generic reference is questioned.

In reddish shaly sandstone, Florence, Colo.

Explanation of Plates

Plate 3. Fig. 1. *Anemia robusta* sp. nov.; Fig. 2. *Stenopteris* (?) *cretacea* sp nov.; Fig. 3. *Gleichenia rhombifolia* sp. nov.; Fig. 4. *Gleichenia delicatula* Heer (?); Figs. 5, 5*a*. *Pecopteris* (*Cheilanthes*) *sepulta* Newb. (?); Figs. 6, 7. *Anemia supercretacea* sp. nov.

Plate 4. Figs. 1, 2. *Asplenium magnum* Knowlton; Figs. 3-6. *Acrostichum Haddeni* sp. nov.; Fig. 7. *Polystichum Hillsianum* sp. nov.

New York Botanical Garden.

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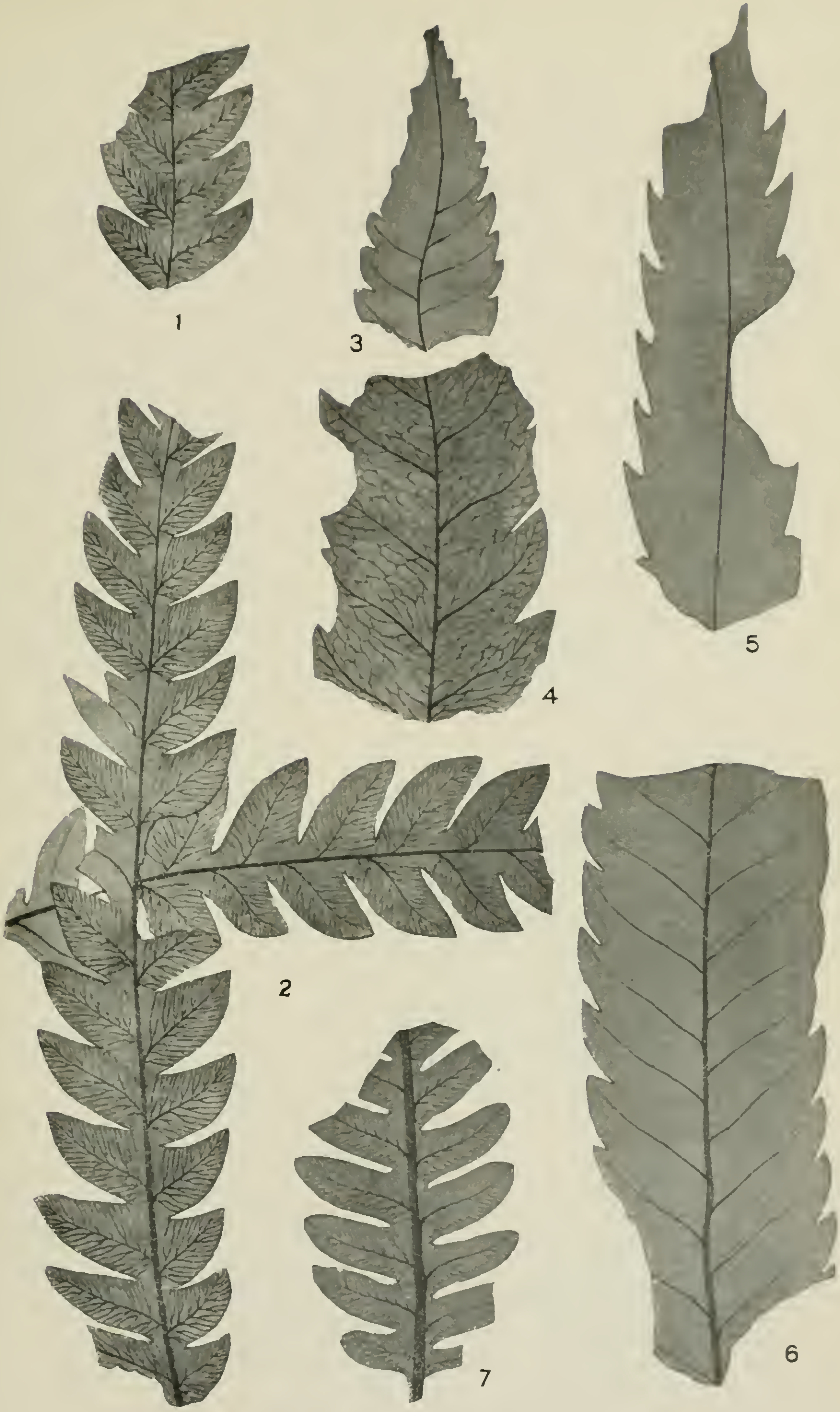
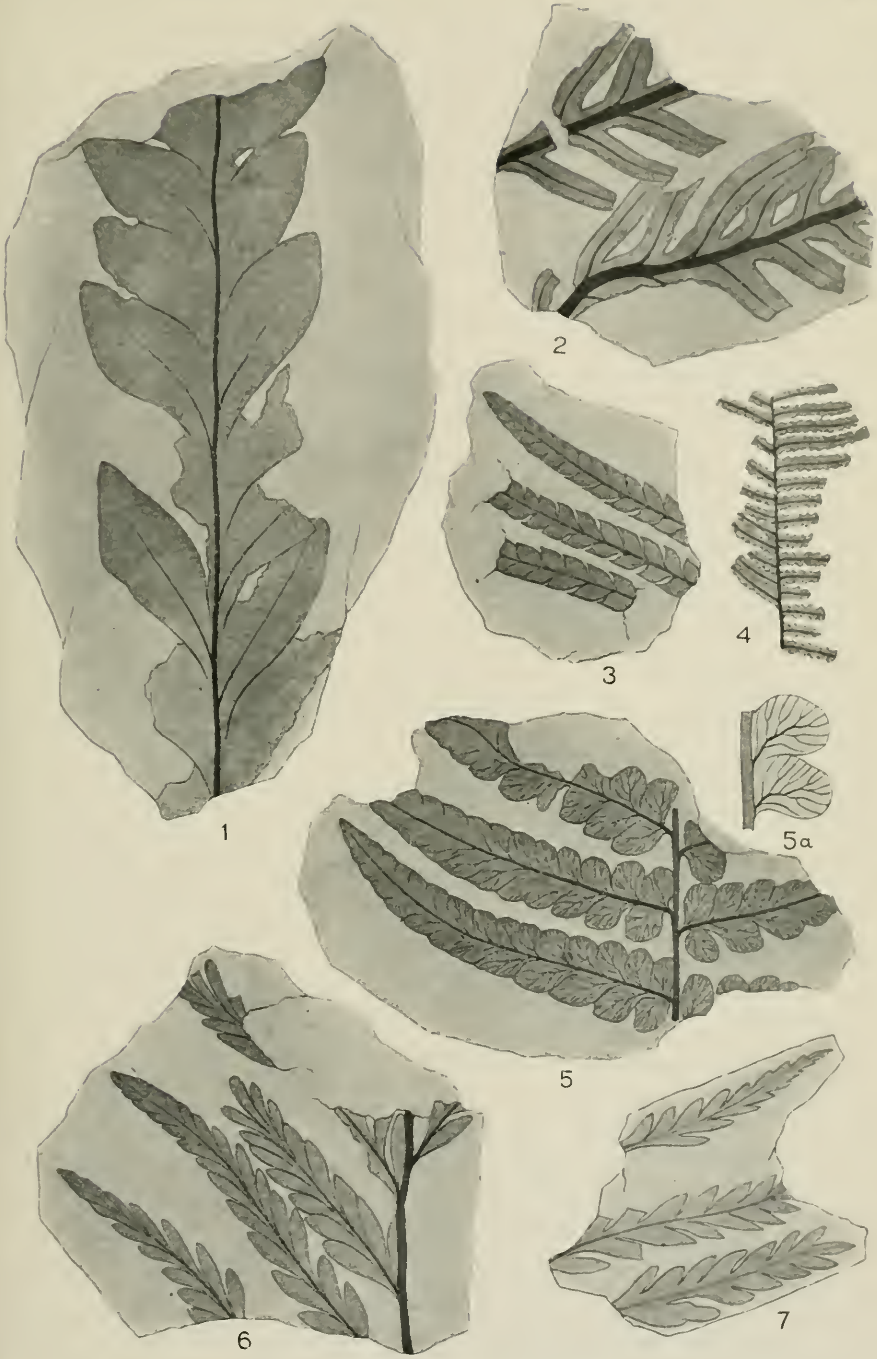
[*] The label denoting the locality was not found, but the matrix is lithologically identical with that of the Walsenberg specimens.



FOSSIL FERNS FROM COLORADO.



FOSSIL FERNS FROM COLORADO.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 29

THE POLYPORACEAE OF NORTH AMERICA.

I. THE GENUS GANODERMA.

By WILLIAM ALPHONSO MURRILL.

NEW YORK
1902

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 29: Oct., 1902.]

The Polyporaceae of North America. I. The Genus Ganoderma*

By William Alphonso Murrill

It is evident, even to the beginner in mycology, that the present classification of the higher fungi is not satisfactory. This is particularly true of the group containing *Polyporus* and its allies, which is at present very imperfectly divided into genera, and contains many species which are confused and uncertain, because of the incompleteness of the original descriptions. Before the group can be reduced to order, full descriptions must be had of all its species, the type specimens in Sweden, England, Germany, and elsewhere must be examined, and sufficient knowledge gained of the life and habits of each plant to determine its natural position in the group. In this paper an attempt is made to present in order the members of the "*lucidus*" group of *Polyporus* occurring in North America. A large number of the specimens examined have been collected during several years past by Professor Lucien M. Underwood, and by various contributors to his private herbarium. The extensive literature and large collections of the New York Botanical Garden and Columbia University have also been most generously placed at the writer's disposal.

I desire also to express my appreciation of the many courtesies extended me by Professor Paul Magnus, Mr. P. Hennings, Professor Kjellman, Professor T. M. Fries, Professor H. Von Post, Mr. Lars Romell, Mr. W. B. Hemsley, Mr. George Massee and others, while studying forms of this group in Germany, Sweden, and England.

History of the Genus

The species upon which this genus was founded was first described in its immature form as an agaric, but when perfect specimens were obtained it was placed in *Boletus*, a genus established by Dillenius in 1719 to include all pore-bearing fungi, and later adopted by Linnaeus, although Micheli had erected the genus *Polyporus* as early as 1729. *Polyporus* was used by Persoon in his Synopsis only as a subgenus under *Boletus*, from which position it was later raised by Fries to equal rank with *Boletus* and made to include the woody forms of pore-bearing fungi. In 1851, Fries tried the experiment of breaking *Polyporus* up into *Fomes*, *Polystictus*, and *Poria*, a division which, though discontinued in his later works was resurrected by Cooke in his *Praecursores* in 1885 and adopted by Saccardo and others since.

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* Read by invitation before the Botanical Society of America, Pittsburg, June, 1902.

When a systematic arrangement of the Polyporaceae of Finland was undertaken by Karsten (Rev. Mycol. 1881), one of the new genera established was *Ganoderma*, which was based upon the laccate character of pileus and stipe and embraced *Polyporus lucidus* only. In Karsten's "Finlands Basidsvampar" published in 1889, *Ganoderma* is characterized as follows: "Basiderna 4-sporiga, n. klotrunda, cystiderna icke anmärknings värda. Sporerna äggrunda eller elliptiska, värtiga, gulbrunaktiga." Although no mention is here made of the laccate pileus and stipe, no other species are included with *G. lucidum* in the genus. As a synonym of *Ganoderma*, Karsten here mentions *Placodes Quél.*, which genus was erected in 1886 to include a variety of forms which were "covered with a hard crust, without zones or concentrically sulcate, persistent, woody." Along with *P. lucidus* in one of the subdivisions are placed also *P. dryadeus*, *P. resinosus*, *P. erubescens*, and *P. helveolus*.

The transfer of *G. lucidum* from *Ganoderma* Karst. to *Phaeoporus* Schroet. in Schroeter's flora of Silesia was a violation of modern principles and consequently could not meet with general favor. In 1887, Patouillard, following the lead of Quélet, extended the range of *Ganoderma* to include all forms of Polyporaceae with colored spores, adhering tubes and shining crusted pilei; and in 1889 he published a partial monograph of the genus as extended, listing forty-eight species, which were arranged in subgroups upon spore characters. As to the wisdom of so broad a treatment of the genus mycologists appear to be divided. The following synopsis includes only those species which, while essentially alike in internal structure, possess a shining varnished surface produced by the exudation and hardening of a reddish juice similar to that found in *G. pseudoboletus*.

Synopsis of the North American Species

1. Context pallid to tawny. 2.
Context umbrinous-chestnut. 5.

2. Spores over 6 μ long, verrucose, ferruginous. 3.
Spores less than 6 μ long, smooth, pale; pileus less than 3 cm. broad, margin entire; tubes not stratified. 4. *G. parvulum.*

3. Context ochraceous to fulvous; plants stipitate or sessile, growing on deciduous trees. 4.
Context pallid; plants usually stipitate, annual, growing on hemlock. 1. *G. tsugae.*

4. Plants stipitate, or rarely sessile, perennial; margin of pileus truncate at maturity. 2. *G. pseudoboletus.*
Plants sessile, annual; margin of pileus acute. 3. *G. sessile.*

5. Spores smooth, pale yellowish-brown. 6.
Spores roughly echinulate, dark brown; pileus sessile, very thick, its diameter decreasing downward; context less than one third the length of the tubes. 5. *G. Oerstedii.*

6. Pileus zonate, even; tubes not stratified. 6. *G. zonatum.*
Pileus sulcate, azonate; tubes stratified. 7. *G. sulcatum.*

1. **Ganoderma tsugae** sp. nov.

A conspicuous reddish-chestnut fungus growing on dead or dying hemlock. Pileus corky to woody, fan-shaped, convex above, concave below, 4–20 × 5–25 × 1–4 cm.;* surface glabrous, uneven, concentrically sulcate, laccate, lustrous, yellowish-red to mahogany-colored, at length black; margin light-yellow, acute, becoming concolorous, truncate, and marked with many shallow furrows, often undulate and at times more or less lobed: context soft-corky, radiate-fibrous, white or nearly so, 1–3 cm. thick; tubes annual, 0.5–0.75 cm. long, 6–4 to a mm., brown within, mouths circular or polygonal, white to light-cinnamon, edges obtuse, becoming acute: spores ovoid, obtuse at the summit, attenuate and truncate at the base, verrucose, yellowish-brown, 9–11 × 6–8 μ: stipe lateral, ascending, frequently forked, cylindrical, equal, 2–20 × 1–4 cm., resembling the pileus in color, surface and context.

This fungus occurs only on *Tsuga Canadensis*, upon the decaying trunks and roots of which it is very abundant. In West Virginia and New York it has been found full grown as early as June, but it may not reach maturity until autumn, when it speedily decays or falls a prey to insects. So subject is it to insect attack that recognizable specimens are rare in the herbarium. As its ordinary host is confined to America, there is no reference to it in European literature, unless the plants found on *Picea excelsa* by Karsten in Sweden belong here rather than with *G. pseudoboletus.*

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* These figures indicate length, breadth and thickness respectively. When the stipe is lateral the pileus is an outgrowth from it and length is measured in the direction of this growth. When the pileus is sessile, the tubercle marking the beginning of growth may be considered a lateral stipe much reduced. When the question of length is settled, breadth and thickness need no explanation.

Extensive collections of various forms of this species were made by Professor Underwood at Syracuse, N. Y., in July 1884, and at West Goshen, Conn., August 1896. Miss A. M. Vail brought specimens from Tyringham, Mass., in August 1897.* Professor G. F. Atkinson has figured the species in plate 66 of his work on mushrooms. Wherever the hemlock grows it appears to be common. It is nearly related to *G. pseudoboletus*, but is annual, grows on coniferous trees, decays soon after maturity, and is usually much lighter in weight and paler in substance.

2. **Ganoderma pseudoboletus** (Jacq.)

Agaricus pseudoboletus Jacq. Flor. Austr. **1**: 26–27. *pl. 41.* 1773.

Boletus rugosus Jacq. Flor. Austr. **2**: 44. *pl. 169.* 1774.

Boletus lucidus Leyss. Flora Halensis, 300. 1783.

Boletus obliquatus Bull. Herb. de la France, *pl. 7.* 1780; *pl. 459.* 1790.

Polyporus lucidus Fries, Syst. Myc. **1**: 353. 1821.

Polyporus laccatus Pers. Myc. Eur. **2**: 54. 1825.

Polyporus Curtisii Berk. Kew Gard. Misc. **1**: 101. 1849.

A large fungus common on decaying trunks and stumps of deciduous trees conspicuous on occount of its brilliant varnished appearance. Pileus corky to woody, usually kidney-shaped, convex above, concave below, 2–20 × 2–25 × 1–5 cm., yellow to reddish-chestnut or black; surface glabrous, shining, laccate, broadly sulcate and usually marked with concentric lines or bands of a darker color; margin white or light yellow, sterile, thin, acute, becoming truncate, sulcate, and concolorous as new strata are added; context soft-corky or woody, radiate-fibrous, concentrically banded, ochraceous above, tawny next to the hymenium: tubes one- to many-layered, the strata varying in distinctness, 0.5–2 cm. long, 3–5 to a mm., brown within; mouths circular to hexagonal, white or yellow, at length brown, dissepiments entire, obtuse, becoming acute: spores ovoid, obtuse, at the summit, attenuate and truncate at the base, yellowish-brown, verrucose, 9–11 × 5–6 μ: stipe lateral, excentric, central, or wanting, erect to ascending, 0–30 × 0.5–4 cm., equal, irregular, or enlarging above, concolorous, glabrous, shining, laccate, the substance similar to the context and darker at the center.

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* During the summer of 1902 fine specimens have been collected in the hemlock grove of the New York Botanical Garden by Messrs. Burnham and George, in Connecticut by Miss White, and in Ohio by Professor A. D. Selby.

On living or dead trunks, stumps, or roots of oak, alder, hazel, maple, willow, honey-locust, sweet-gum, and beech in Sweden, Germany, Bavaria, France, England, America and Australia. American material has been examined from New York, New Jersey, Delaware, Pennsylvania, Ohio, Indiana, Kentucky, Michigan, Virginia, North Carolina, South Carolinia, Georgia, Florida, Alabama, Mexico, and Nicaragua.

This fungus has been found fossil in the lake dwellings of Switzerland and has been known for a long time on account of its conspicuous coloring caused by a thick glutinous juice which exudes from its surface and dries upon it as a thin lustrous coating. Albino or semi-albino forms occur where the coating is lacking or incomplete. In age the varnish disappears and the pileus takes on a grayish weather-beaten appearance. As the young pileus begins to form at the end of the stipe it is white or yellow in color without varnish and somewhat resembles an unexpanded agaric. It is this stage that Jacquin figured and described in his Flora Austriaca as *Agaricus pseudoboletus.* Several immature plants were found by him in a grove growing about the base of a dead oak trunk. The description he gives is quite a good one and, taken with the fine colored plate, leaves no doubt as to the identity of the specimens. The succeeding year he collected several mature plants which he described as *Boletus rugosus* as follows:—

> "Fungus speciosus putridis arborum truncis innascitur, totus lignoso-coriaceus et persistens. Stipes durus, inaequalis, badius, vernice veluti obductus, calamum vel policem crassus ratione voluminis ipsius fungi, pileum gerit plerumque subdimidiatum, dum laterali ejusdem parti adnecitur. Hic superne planus est, rugosus primum, ex rubro badius et nitidissimus, tandem hepaticus minusque nitens. Corticis pauca substantia est interne coriacea, holoserisea, cinnamomea, tenax atque ad fomitem apta. Substantia tubulosa concolor, crassa, a corticosa separabilis, subtilissime porosa; subtus punctata, in principio pallens, sensim magis cinnamomea; ad cibum inepta. Fungi duo, ex eodem loco exorti, et majores, in tabula proponuntur, hinc atque illinc spectati. Tum fungulus minor; et fungi pars, ut pateant interiora."

The specimen upon which Leysser's *Boletus lucidus* is founded was collected by Curtis on a decaying hazel stump near London in November, 1780, and figured in Flora Londinensis, **4**: *pl. 224.* Leysser's description is as follows: —

> "*Boletus lucidus stipitatus, pileo coriaceo castaneo lucido sulcis circularibus, poris minutissimis, albis, stipite laterali.*"

Specimens collected by Rev. M. A. Curtis in South Carolina seemed to Berkeley sufficiently distinct from Leysser's plant to constitute a new species, which he thus describes in Kew Garden Misc. **1**: 101. 1849: —

> "Pileus excentric, soft-corky, sulcate, zonate, ochroleucous, in places sanguine-lacquered; stipe elongated, rugose, sanguine-lacquered; hymenium from white to ochraceous, pores punctiform."

A special study of many specimens called *Polyporus Curtisii* Berk. shows them to be only variations of *G. pseudoboletus* due to age, rapidity of growth, and perhaps to differences in the host. The yellowish form so common in the southern part of the United States is figured by Bulliard and Gillet as also occurring in France, while farther north the color is usually darker and more lustrous, the texture firmer, and the hymenium less stratose. These differences are not sufficiently constant, however, to enable one to separate the forms geographically.

Another interesting variation observed by Langlois in Louisiana is so distinct from the ordinary form of the plant that it might easily deceive the skilled mycologist. Specimens in the Underwood herbarium have the stipe exactly central, the pileus very even and thin, at first deeply infundibuliform with white margin, at length becoming nearly plane, reddish-brown, and polished, with the margin concolorous.

3. **Ganoderma sessile** sp. nov.

A large sessile plant, with wrinkled varnished cap and acute margin, found on decaying deciduous trees. Pileus corky to woody, dimidiate, sessile, imbricate or connate at times, conchate, thickest behind, thin at the margin, 5–15 × 7–25 × 1–3 cm., yellow to reddish-chestnut, at length opaque dark brown; surface glabrous, laccate, shining, radiate-rugose, concentrically sulcate, usually marked near the margin with alternating bay and tawny zones; margin very thin and acute, usually curved downward, often undulate, not becoming truncate, white, at length concolorous: context soft-corky or woody, radiate-fibrous, concentrically banded, ochraceous-fulvous; tubes 0.5–2 cm. long, 5–3 to a mm., brown within, mouths circular or angular, white to grayish-brown, edges thin, entire: spores ovoid, obtuse at the summit, attenuate and truncate at the base, verrucose, yellowish-brown, 9–11 × 6–8 μ.

This species occurs on deciduous trees and has the general habit of *G. pseudoboletus*, from which it differs in being annual and sessile, with a very acute margin and a more rugose surface. So far as I have been able to determine, it does not occur in Europe, and has not yet been figured. Specimens have been collected by Professor L. M. Underwood on decaying oak at Greencastle, Ind., Oct. 1894, and at White Plains, N. Y., May 1897, and on dead sycamore at Fort Lee, N. J., May 1899, and March 1901. Plants collected by Morgan in the Miami Valley, Ohio, Dec. 1894, were placed under *G. pseudoboletus* and referred to in the following note: "As it grows in this region, the stipe is always more or less deformed and often wanting; the pilei, when sessile, are sometimes imbricated and connate." In Dec. 1896, it was found by C. F. Baker, at Auburn, Ala., and in Nov. 1897, Rev. A. B. Langlois collected it near St. Martinsville, La., on decaying logs in low woods and marked it "Perhaps a form of *F. lucidus?*" Miss Sadie F. Price has recently sent to the New York Botanical Garden from Bowling Green, Ky., two specimens of this plant collected on oak in Nov. 1901, and Feb. 1902. Specimens sent to Kew by American collectors are included there under *G. pseudoboletus.*

4. **Ganoderma parvulum** sp. nov.

A very small sessile fungus shining bay above and honey-yellow below. Pileus woody, nearly circular in outline, attached by a point, convex above, plane or convex below, thickest behind, 2 × 2.5 × 1 cm.; surface glabrous, laccate, azonate, slightly tubercular, very lightly marked with a few concentric furrows, margin acute: context soft-woody, pale ochraceous, 0.5 cm. thick, with dark horny radiations from the point of attachment: tubes not stratified, 3 mm. long, 5 to a mm., umbrinous within, mouths polygonal, honey-yellow, dissepiments entire, obtuse: spores subglobose, smooth, pale yellowish-brown, 4 × 5 μ.

Collected by C. L. Smith in Nicaragua during the winter of

1891–1892. This beautiful little plant is closely related in habit and general appearance to the American species of *Ganoderma* occurring farther north, but it is of much smaller size and its spores are quite distinct in form, size and color. It is possible that the specimens I have are not quite mature.

5. **Ganoderma Oerstedii** (Fries)

Polyporus Oerstedii Fries, Nov. Sym. 63. 1851.

Pileus reniform, ungulate-applanate, gibbous at the base, a foot in diameter; surface horny-incrusted, very glabrous, adorned with shallow furrows, which almost disappear with age, shining reddish chestnut becoming almost black; margin very obtusely truncate and marked with concentric furrows, the upper annual growths exceeding the lower; context partly hard and horny and partly floccose, umbrinous next to the tubes, more tawny beneath the cuticle, very thin in older specimens, the tubes forming the principal part of the pileus: tubes contiguous and hence indistinctly stratified, 3–5 cm. long, umbrinous within, mouths lighter in color, dissepiments entire, obtuse: spores broadly ellipsoid, truncate, very dark yellowish-brown, abundantly and roughly echinulate, $11 \times 9 \mu$.

Two imperfect specimens of this plant are in the herbarium of the New York Botanical Garden, one collected by C. L. Smith in Nicaragua, and the other by C. T. Townsend on an orange tree in Jamaica. These specimens, while corresponding with the Friesian types at Upsala, hardly justify any considerable departure from the Friesian description.

6. **Ganoderma zonatum** sp. nov.

A soft laccate fungus of medium size marked with numerous tawny and chestnut-colored zones. Pileus very soft-corky, sessile, dimidiate, applanate or convex above, concave below, glabrous, zonate, not sulcate, $5 \times 7 \times 1.5$ cm.; margin velvety, acute, becoming obtuse and concolorous: context very soft, floccose, radiate-fibrous, concentrically banded, 0.5 cm. thick, chocolate-brown: hymenium velvety, not stratose, tubes 1 cm. long, 3–4 to a mm., umbrinous within; mouths white to umbrinous, regular, polygonal, stuffed at first with whitish material, covered 0.5–2 cm. from the margin with yellowish or reddish varnish; dissepiments entire, obtuse to acute: spores elongated ellipsoid, smooth, pale yellowish-brown, $8–10 \times 4–6 \mu$.

Collected by Professor Underwood in Florida. Closely related to *G. sulcatum*, but differing in general appearance, size of pores, and in the extent and arrangement of varnish upon the hymenium. A similar coating of varnish exists in *G. sulcatum* and *G. pseudoboletus* at times, but in neither of these has it been found as a broad distinct marginal band. This band is sometimes split by the growth of the margin and a zone of pores appears between the two laccate portions. Additional material may reveal the existence of intermediate forms connecting this species with *G. sulcatum*.

7. **Ganoderma sulcatum** sp. nov.

A large sessile plant without zones, but marked with a few conspicuous concentric furrows. Pileus corky, dimidiate, sessile or arising from a lateral tubercle, plane or convex above, thickest behind, 8 × 11 × 2 cm.; surface laccate, glabrous, azonate, fulvous to chestnut, deeply sulcate; margin rounded, velvety, ochroleucous, at length concolorous: context very soft, floccose, radiate-fibrous, concentrically banded, 1 cm. thick, umbrinous-chestnut: tubes indistinctly stratified, 1.25 cm. long, 4–5 to a mm., umbrinous within, mouths whitish or yellowish, at length umbrinous, dissepiments entire, obtuse: spores ellipsoid, pale yellowish-brown, smooth, 8–10 × 4–6 μ.

This plant was collected on soft palmetto logs in Florida by Mr. C. G. Lloyd, January, 1897; type in New York Botanical Garden. It is very nearly related to *G. zonatum*.

SPECIES INQUIRENDAE

Fomes incrustatus Fries, collected in Costa Rica by Oersted. Pileus 5–7 cm. broad, sordid umbrinous, laccate: context scanty, pallid, tubes concolorous; stipe central, torulose, unequal. This species was not transferred by Patouillard to the genus *Ganoderma*.

G. nutans (Fries) Pat., also collected by Oersted in Costa Rica. Pileus scarcely 2 cm. broad, orbicular, pallid to bay-black, laccate; context scanty, pallid, pores pallid to brown; stipe long, slender, twisted as though climbing, recurved at the apex, giving the pileus the appearance of nodding; spores ovoid, brown, echinulate, 12–15 × 10 μ.

Specimens seen in foreign herbaria appear to be very distinct. Fries' description in Novae Symbolae 61–62 is quite full and cannot be improved upon at this time on account of lack of material for critical study.

G. nitens (Fries.) Pat. On trunks in tropical America. Pileus large, sessile, semiglobose, chestnut to black, shining, hanging by a process behind; context umbrinous, tubes very long and slender. It is quite possible that this is not a distinct species.

G. neglectum Pat. Pileus sessile, 8–10 cm. broad, reddish-black, shining; context brown, tubes white, very short; spores globose, yellow, roughly echinulate, 11 — 12 μ. On trunks in Nicaragua.

NEW YORK CITY.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 30.

STUDIES ON THE ROCKY MOUNTAIN FLORA—IX

By P. A. RYDBERG

NEW YORK
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Studies on the Rocky Mountain Flora—IX

By P. A. Rydberg

THE NYCTAGINIACEAE OF THE ROCKY MOUNTAIN REGION

The family Nyctaginiaceae has been sorely neglected by the systematic botanists in this country. Until lately we have had not even an attempt at a monographic work since Dr. Gray's notes were published in the Botany of the United States and Mexican Boundary Survey in 1859. Gray's treatment there as a whole can scarcely be regarded as an improvement on that by Choisy, published ten years earlier in De Candolle's Prodromus, and of course, both are now out of date. Professor Heimerl's treatment in *Die natürlichen Pflanzenfamilien* is as good as could be expected from a European monographing an almost exclusively American family; but this gives little help beyond the genera. Recently there has appeared a revision of the family by Marcus E. Jones * as it is represented on the Great Plateau. As the territory covered by Jones practically includes that treated in this article, it would seem superfluous to duplicate the work; but I have had the advantages of a large library and the rich collections of Columbia University, the United States National herbarium, and the New York Botanical Garden. These advantages are, however, somewhat balanced by Mr. Jones' longer field experiences. Jones' paper is valuable because it gives fuller descriptions of many poorly known species, descriptions drawn by a botanist who knows the species in the field. It is deplorable, however, that this paper in many places shows a good deal of carelessness, especially in the matter of citing publications. Under *Allionia*, it has for instance:

"5. A. GLABER † (Wats.) Kuntze, Am. Nat. 76," and

"7. A. AGGREGATA (Vahl) Spreng. Ic. 5 437."

In the first case, one would suppose that Kuntze published the combination in the American Naturalist, while the fact is that Watson there published *Oxybaphus glaber*, on which *Allionia glabra* is based.

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* Contributions to Western Botany, 10 : 34–54. June, 1902.

† This should have been *A. glabra*.

If interpreting the second case in a similar way, one would come to the conclusion that *Oxybaphus aggregatus* Vahl was published in Vahl's Icones, if not in Sprengel's Icones ; but neither is the case, for no book with that title was ever published by either Vahl or Sprengel. From Mr. Jones' citation no one could imagine that Ic. 5 437, stands for Cavanilles' Icones, where *Mirabilis aggregata* appeared. This is not the earliest appearance of the name *aggregata*, however, for this was originally published by Ortega * as *Calyxhymenia aggregata*. As Cavanilles' plant is different from Ortega's, the former being *Allionia decumbens* (Nutt.) Spreng., the latter *A. agregata* (Ortega) Spreng. as shown below, Jones citation becomes not only unintelligible but also incorrect. It would have been much better to leave out the citation of publications altogether, which by the way is advisable for anyone who does not possess good library facilities.

Key to the Genera of the Rocky Mountain Region

Bracts distinct.
  Fruit crested or winged ; bracts in a whorl at the base of the head-like cluster ; perianth salverform. 1. *Abronia.*
  Fruit globular, neither crested nor winged ; bracts attached each to a pedicel of the umbel-like or corymbose inflorescence ; perianth funnelform. 2. *Hermidium.*
Bracts united.
  Fruit neither strongly tubercled nor winged.
    Fruit not ribbed ; involucre herbaceous, little if any enlarging in fruit, not becoming membranous.
      Stamens usually 5 ; involucres campanulate, not enlarged in fruit. 3. *Quamoclidion.*
      Stamens 3 ; involucre rotate, somewhat enlarged in fruit in the manner of the next genus, but not membranous. 4. *Allionella.*
    Fruit ribbed ; involucre rotate, in fruit becoming much enlarged and membranous. 5. *Allionia.*
  Fruit with two rows of strong tubercles on the back and surrounded by two toothed inflexed wings. 6. *Wedelia.*

1. ABRONIA Juss. Gen. 448. 1789

Tricratus L'Her. ; Willd. Sp. Pl. **1** : 807. 1799.

Cycloptera Nutt. ; Gray, Am. Jour. Sc. II. **15** : 319. 1853.

In the original publication, no type species was mentioned. The genus was described from a plant collected on De la Peirouse's journey in California and cultivated by Mr. Colignon. Hooker in his Exotic Flora, *pl. 193 & 194*, identifies Colignon's plant as *Abronia umbellata*. The type of *Tricratus* is the same, and that of *Cycloptera* is *A. cycloptera*.

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* Nov. aut Rar. Pl. 8 : *pl. 11.* 1798 (or 9 ?).

Fruit narrowly winged or crested; wings or crests not completely encircling the fruit.

Fruit biturbinate, *i. e.*, tapering at both ends, irregularly ridged or crested.

Flowers about 2 cm. long; limb 5–10 mm. wide.

Bracts broadly obovate, over 1 cm. long. 1. *A. fragrans.*

Bracts ovate-lanceolate, less than 1 cm. long. 2. *A. nudata.*

Flowers about 1 cm. long; limb 3–5 mm. wide; bracts ovate to lanceolate-ovate, about 5 mm. long.

Petioles of the stem-leaves shorter than the very thick blades; plant low, about 1 dm. high. 3. *A. pumila.*

Petioles of the stem-leaves much longer than the moderately thick blades; plant slender, 2–4 dm. high. 4. *A. ammophila.*

Fruit turbinate or obpyramidal, *i. e.*, almost truncate above, distinctly winged; the wings very broad above.

Plant almost acaulescent; stem and leaves greatly surpassed by the long peduncles. 5. *A. nana.*

Plant with an elongated stem.

Bracts broadly ovate or obovate, acute or obtusish.

Stem distinctly viscid-pubescent; leaves scabrous-puberulent; bracts 1–1.5 cm. long.

Blades of the stem-leaves elliptic; bracts broadly obovate, 12–15 mm. wide, obtusish. 6. *A. salsa.*

Blades of the stem-leaves lanceolate; bracts oval, acute, about 6–7 mm. wide. 7. *A. fallax.*

Stem finely puberulent or glabrous; leaves glabrous; bracts 5–8 mm. long.

Stem puberulent. 8. *A. elliptica.*

Stem glabrous. 9. *A. glabra.*

Bracts oblong-lanceolate or lanceolate, attenuate or cuspidate.

Stem glabrous. 10. *A. lanceolata.*

Stem more or less pubescent.

Stem puberulent; wings with double lamina, coriaceous. 11. *A. Carletoni.*

Stem villous; wings with single lamina, membranous. 12. *A. villosa.*

Fruit completely surrounded by the broad netted-veined membranous wings.

Flowers 3 cm. or more long; limb about 1 cm. wide; peduncles longer than the leaves. 13. *A. cycloptera.*

Flowers 1.5–2 cm. long; limb about 5 mm. wide.

Stem glabrous or nearly so; peduncles often nearly equalling the leaves. 14. *A. pedunculata.*

Stem densely pubescent; peduncles at least in flower much shorter than the leaves. 15. *A. micrantha.*

1. ABRONIA FRAGRANS Nutt.; Hook. Kew Journ. 5: 261. 1853

On the plains from South Dakota to Montana, Idaho, New Mexico and Kansas.

2. **Abronia nudata** sp. nov.

Perennial, stems very long and decumbent, sparingly hispidulous: leaves thick, glabrous; petioles 2–10 mm. long; blades broadly lanceolate, obtusish, 2–5 cm. long: peduncles 4–6 cm. long, almost glabrous: bracts ovate-lanceolate, less than 1 cm. long: flowers many, about 2 cm. long; limb 5–6 mm. wide: achenes very irregular, the inner ones of the head bipyramidal, thickest a little above the middle, crested, 8–10 mm. long, those of the margin very obliquely ovoid-fusiform, scarcely at all crested.

This species is nearest related to *A. fragrans* and *A. ammophila.* From the former it differs in the small bracts, smaller leaves and almost glabrous stem; and from the latter in the much longer flowers and the scanty or no pubescence.

MONTANA: Colgate, near Glendive, 1892, *Sandberg, MacDougal & Heller, 1016* (type in herb. N. Y. Bot. Garden).

3. **Abronia pumila** sp. nov.

Perennial, caespitose: stems ascending, about 1 dm. long, puberulent: leaves very thick, minutely puberulent; petioles 1–2 cm. long, those of the stem-leaves usually shorter than blades; these 1.5–3 cm. long, oval, elliptic or somewhat ovate: peduncles 2–3 cm. long, puberulent: bracts elliptic-ovate or lanceolate, 7–8 mm. long, short-acuminate: flowers about 12 mm. long; limb about 3 mm. wide: fruit bipyramidal, *i. e.*, tapering towards both ends but more so downwards, the greatest breadth being about one third from the apex, merely crested or the inner ones somewhat winged.

Dr. Heimerl referred this to *A. truncata* Torr., but the fruit is very unlike that of that species. *A. pumila* is nearest related to *A. ammophila*, from which it differs mainly in the thicker and short-petioled leaves and the dwarfed habit.

UTAH: Emery, 1894, *M. E. Jones, 5445g* (type in U. S. Nat. herb.); six miles up Salida Cañon, *5416a*.

4. ABRONIA AMMOPHILA Greene, Pittonia, **4**: 226. 1900

Abronia arenaria Rydb. Mem. N. Y. Bot. Garden, **1**: 137. 1900. Not Menz. 1827.

Yellowstone National Park.

5. ABRONIA NANA S. Wats. Proc. Am. Acad. **16**: 294. 1870

Southern Utah to Arizona and southern California.

6. **Abronia salsa** sp. nov.

Abronia fragrans S. Wats. King's Rep. 5: 284. 1871. Not Nutt.

Perennial: stem ascending, 3–4 dm. high, densely viscid-pubescent especially above, stout: leaves very thick, puberulent; petioles 2–3 cm. long; blades oval or elliptic, obtuse, or the lowest rounded oval, 3–5 cm. long, 1–3 cm. wide: peduncles 5–7 cm. long, densely viscid-pubescent; bracts rounded obovate, about 15 mm. long and often as broad, pubescent: flowers many, about 2 cm. long with a limb about 4 mm. wide: fruit about 1 cm. long, similar to those of *A. lanceolata* and *A. fallax* but the wings are rather thicker.

The sheets in the National Herbarium bear the following labeling by Dr. Heimerl: "*Abronia fragrans* Nutt. (*ad formam* **ellipticam** (Nelson) *accidens!*);" but neither *A. salsa* nor *A. elliptica* A. Nelson have the fruit of *A. fragrans*, and therefore can not be regarded as forms of that species. *A. salsa* differs from *A. elliptica* in the stouter viscid-pubescent stem, the larger bracts and flowers. It grows in sandy saline soil at an altitude of 1000–1300 m.

UTAH: Salt Lake City, 1869, *S. Watson*, *965* (type in herb. Columbia University); same locality, *Capt. Stansbury*, and 1871, *Hayden;* Silver Reef, 1894, *M. E. Jones;* Grand Junction, 1900, *S. G. Stokes.*

7. **Abronia fallax** Heimerl sp. nov.

Perennial; stem erect, almost shrubby below, branched, straw-color or white, viscid-pubescent above: leaves thick, puberulent, erect; petioles 1–2 cm. long; blades of the lower oval, of the upper long-lanceolate, 2–5 cm. long, 1–1.5 cm. wide, obtuse or the upper acute: peduncles 1–2 cm. long, densely viscid-pubescent; bracts 5–6, oval, about 1.5 cm. long, 6–7 mm. wide: flowers many, about 15 mm. long: fruit with the wings about 6 mm. wide and 8 mm. long, cuneate-obpyramidal.

The type in the U. S. Nat. herbarium bears the following remarks from the hand of Dr. Heimerl: "*Abronia fallax m.—? Hybrida ex A. fragrans et A. turbinata.—Ab A. fragrans anthocarpinis alis apice transverse dilatatis, ab A. turb. bracteis capitulorum magnis, scariosis diversa.*"* To me it seems that the plant has little to do with *A. fragrans* and is less related to *A. turbinata* than to *A. elliptica* A. Nelson. From this it differs in the upright stem, which is decidedly viscid-pubescent instead of merely puberulent.

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* In a letter lately received from Dr. Heimerl, he has authorized me to use his name and notes.

UTAH: Salt Lake City, 1879, *M. E. Jones, 1337* (type in U. S. Nat. herb., also in herb. Columbia University).

8. ABRONIA ELLIPTICA A. Nelson, Bull. Torrey Club, **26**: 7. 1899

Wyoming and Colorado.

9. **Abronia glabra** sp. nov.

Perennial: stem ascending, about half a meter high, glabrous, straw-colored: leaves thick, glabrous; petioles 1–2 cm. long; blades oval to oblong, 1–4 cm. long, obtuse: peduncles oval, 2–4 cm. long, glabrous; bracts obovate or about 5 mm. long, acute: flowers 12–15 mm. long, numerous: fruit cuneate-obpyramidal, with the wings 4–5 mm. wide and 7–8 mm. long: wings very thick, of two lamina, semi-cordate at the apex: wingless tip of the fruit very short.

This species is intermediate between *A. elliptica* and the next species. From the former it differs in the glabrous stem and the stricter habit, from the latter in the broader and shorter bracts and the smaller flowers.

COLORADO: Grand Junction, 1883, *M. E. Jones* (type in U. S. Nat. herb.).

10. **Abronia lanceolata** sp. nov.

Perennial: stem glabrous, decumbent, several decimeters long: leaves rather thick, glabrous; petioles 2–3 cm. long; blades oblong-oval, 2–5 cm. long, 1–1.5 cm. wide: peduncles 5–15 cm. long; bracts 6–8, lanceolate, acute or acuminate, about 1 cm. long: flowers numerous, about 1.5 cm. long, with a limb 4–5 mm. wide: fruit with the thin wings about 8 mm. wide and about as long, cuneate-obpyramidal in outline, puberulent: wings strongly reticulate, semicordate at the apex, where the tip of the achene extends for about 2 mm.

The type was labeled *A. fragrans*, which species it resembles in general habit, but it is easily distinguished both by the narrow bracts and the strongly winged fruit. These characters place it nearer *A. Carletoni* Coult. & Fisher which is of a different habit and has a puberulent stem. *A. lanceolata* grows in drifting sand.

IDAHO: Idaho Falls, 1901, *Merrill & Wilcox, 870.* (Type in herb. N. Y. Botanical Garden.)

11. ABRONIA CARLETONI Coult. & Fisher, Bot. Gaz. **17**: 349. 1892

Colorado.

12. ABRONIA VILLOSA S. Wats. Am. Nat. **7**: 302. 1873

Southern Utah to Arizona and California.

13. ABRONIA CYCLOPTERA A. Gray, Am. Journ. Sci. II. **15**: 319. 1853

From Wyoming to Texas and Arizona.

14. **Abronia pedunculata** (M. E. Jones)

Abronia micrantha pedunculata M. E. Jones, Proc. Cal. Acad. II. **5**: 716. 1895.

In the Navajo Basin of eastern Utah.

15. ABRONIA MICRANTHA Torr. Frem. Rep. 96. 1845

From South Dakota to Montana and New Mexico.

2. HERMIDIUM S. Wats. King's Rep. **5**: 296. 1871

A monotypic genus.

1. HERMIDIUM ALIPES S. Wats. *l. c.*

Nevada and western Utah.

3. QUAMOCLIDION Choisy; DC. Prod. **13**^{2}: 429. 1849

This genus was based on two species, of which the second was referred doubtfully to the genus. The first had before been known as a species of *Mirabilis*, viz.,-*M. triflora* Benth. The type of the genus *Mirabilis* L. is *M. Jalapa* L. In the latter the filaments are united at the base, the fruit is not viscid and the corolla is salver-shaped with a long tube and broad limb. In *Quamoclidion* the filaments are distinct, the fruit viscid and the corolla from nearly cylindrical to bell-shaped but with a small limb. In *Mirabilis* the flowers are solitary and in the typical species of *Quamoclidion* 3–6 in the involucre; but as the number of flowers are not of value as a generic character I have here included a species with one-flowered involucres.

Involucre 5–6-flowered: perianth elongated funnelform. 1. *Q. multiflorum.*
Involucre 1-flowered: perianth open-campanulate. 2. *Q. laeve.*

1. QUAMOCLIDION MULTIFLORUM Torr.; Gray, Am. Journ. Sc. II. **15**: 321. 1853

Oxybaphus multiflorum Torr. Ann. Lyc. N. Y. **2**: 237. 1828.

Nyctaginia Torreyana Choisy; DC. Prod. **13**^{2}: 430. 1849.

Mirabilis multiflora A. Gray; Torr. Bot. Mex. Bound. 173. 1859.

Choisy, who had not seen any specimens of this species and who believed that it had distinct bracts, referred it to *Nyctaginia;* but it is evidently congeneric with and closely related to *Mirabilis triflora* Benth., the type of *Quamoclidion.* *Q. multiflorum* ranges from Colorado and New Mexico to Arizona and California.

2. **Quamoclidion laeve** (Benth.)

Oxybaphus laevis Benth. Bot. Sulph. 44. 1844.

O. glabrifolius var. *crassifolius* Choisy; DC. Prod. **13**^{2}: 431. 1849.

O. glabrifolius Torrey, Pac. R. R. Rep. **4**: 131. 1857. Not Vahl.

Mirabilis Californica A. Gray; Torr. Mex. Bound. Surv. 173. 1859.

O. Californicus Benth. & Hook. Gen. **3**: 4. 1880.

This species has quite often been included in *Oxybaphus, i. e., Allionia*, and often in *Mirabilis.* Professor Heimerl, in his treatment of the Nyctaginiaceae in *Die natürlichen Pflanzenfamilien*, merges *Oxybaphus* into *Mirabilis;* but associates this species with the one-flowered species of *Allionia.*

It is evident that if *Allionia* is to be treated as a distinct genus, *Q. laeve* can not be included in the latter genus for it lacks the essential characters, viz., the ribbed fruit and the enlarging and membranous involucre. It is evidently closer related to *Quamoclidion* than any other genus. The only important difference between it and the typical species is the open short perianth and the flowers solitary within each involucre. The species ranges from Utah to Arizona and California.

4. **Allioniella** gen. nov.

Bracts five, united into a gamophyllous viscid rotate involucre, which enlarges somewhat in fruit but does not become membranous: flowers in each involucre 3: perianth open, short funnelform: stamens 3, distinct: fruit ellipsoid, neither angled nor ribbed, very indistinctly tubercled, glabrous.

Only one species.

1. **Allioniella oxybaphoides** (A. Gray)

Quamoclidion oxybaphoides A. Gray, Am. Journ. Sc. II. **15**: 320. 1853.

Mirabilis oxybaphoides A. Gray, Bot. Mex. Bound. Surv. 173. 1859.

Oxybaphus Wrightii Hemsl. Biol. Cent. Am. **3**: 3. 1882.

Allionia oxybaphoides Kuntze, Rev. Gen. 533. 1891.

From the many synonyms can be seen that this species has been moved from one genus to another. Most botanists have regarded it as an *Allionia* (*Oxybaphus*), which it resembles most in general habit, the perianth and the number of stamens; but it lacks the most essential characters of that genus, viz., the ribbed fruit and the membranous involucre. It is, therefore, more closely related to the *Mirabilis* series; and could be included in genus *Quamoclidion* had it not the open *Allionia*-like perianth, only three stamens and a flat rotate involucre. It is, therefore, better to regard it as the type of a new genus, intermediate between *Allionia* and *Quamoclidion*.

A. oxybaphoides grows from southern Colorado to western Texas and Arizona; also in northern Mexico.

5. ALLIONIA Loefl. It. Hisp. 181. 1758

Vitmania Turra; Cav. Ic. **3**: 53. 1794. Not *Vitmannia* Vahl. 1794.

Oxybaphus L'Her.; Willd. Sp. Pl. **1**: 185. 1797.

Calyxhymenia Ortega, Nov. aut Rar. Pl. Hort. Matr. 5. 1797.

Calymenia Pers. Syn. **1**: 36. 1805.

The genus was based on a plant which a year later received the specific name *A. violacea* L. *Vitmania* and *Oxybaphus* were both based on *Mirabilis viscosa* Cav.; *Calyxhymenia* on *C. glabrifolia* and *Calymenia* on six species without the type being designated.

Key to the Species

Leaves from cordate to broadly ovate-lanceolate : all distinctly petioled.

Leaves cordate. 1. *A. nyctaginea.*

Leaves ovate, rounded or cuneate at the base. 2. *A. floribunda.*

Leaves ovate-lanceolate, oblong or linear, sessile or only the lower short-petioled.

Involucres in open terminal cymes.

Stem more or less hirsute as well as viscid.

Leaves ovate or broadly oblong, as well as the stem conspicuously hirsute. 3. *A. hirsuta.*

Leaves linear-lanceolate, almost glabrous ; stem sparingly hirsute or glabrous except under the nodes. 4. *A. pilosa.*

Stem glabrous below, not hirsute, viscid-puberulent above.

Flowers solitary in the involucre on short slender pedicels ; fruit nearly glabrous. 5. *A. glabra.*

Flowers 2–3 in the involucres, subsessile ; fruit decidedly pubescent.

Leaves of the cymes much reduced and bract-like, upper portion of the stem densely and finely puberulent. 6. *A. bracteata.*

Leaves of the cymes neither much reduced nor bract-like.

Leaves erect or ascending ; lobes of the involucre rounded or broadly triangular-ovate.

Plant prostrate or diffuse ; involucres and branches of the inflorescence densely viscid hairy. 7. *A. diffusa.*

Plants more simple, erect or ascending ; branches of the inflorescence usually merely viscid-puberulent.

Leaves from ovate or obovate to linear-lanceolate, usually over 5 mm. wide. 8. *A. lanceolata.*

Leaves narrowly linear, less than 5 mm. wide. 9. *A. linearis.*

Leaves divergent ; lobes of the involucre elliptic or oval. 10. *A. divaricata.*

Involucres on solitary axillary peduncles, rarely also in small dense terminal clusters.

Leaves oblong, lanceolate or linear-lanceolate.

Stem hirsute. 11. *A. aggregata.*

Stem glabrous. 12. *A. decumbens.*

Leaves narrowly linear. 13. *A. Bodinii.*

1. ALLIONIA NYCTAGINEA Michx. Fl. Bor. Am. **1** : 100. 1803

Oxybaphus nyctagineus Sweet, Hort. Brit. **1** : 334. 1825.

A well-known and common plant growing in rich soil from Illinois and Saskatchewan to Wyoming, New Mexico and Louisiana.*

2. ALLIONIA FLORIBUNDA (Choisy) Kuntze, Rev. Gen. 533. 1891

A. ovata Pursh, Fl. Am. Sept. **1** : 97. 1814. Not *Oxybaphus ovatus* Vahl. 1806.

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* *Allionia Cervantesii* has been reported from Colorado, but the specimens on which this assertion has been made belong in all cases I know to *Allioniella oxybaphoides*.

O. floribundus Chois ; DC. Prod. **13**^{2}: 433. 1849.

A. nyctaginea ovata Morong, Mem. Torrey Club, **5** : 146. 1894.

In dry soil from Missouri and South Dakota to Wyoming, New Mexico and Texas.

3. ALLIONIA HIRSUTA Pursh, Fl. Am. Sept. **2** : 728. 1814

Oxybaphus hirsutus Sweet, Hort. Brit. **1** : 334. 1825.

In sandy soil from Minnesota and South Dakota to Colorado.

4. **Allionia pilosa** (Nutt.)

Calymenia pilosa Nutt. Gen. **1** : 26. 1818.

Oxybaphus pilosus Sweet, Hort. Brit. **1** : 334. 1825

This has been confused with the preceding, but I think it amply distinct. So it was regarded by Nuttall and by Sweet. It is perhaps nearer related to *A. floribunda* and Nuttall cites *A. ovata* Pursh as a synonym ; but it is well to note that Nuttall describes the stem of his species as pubescent, which does not agree with Pursh's plant. *A. pilosa* grows in dry sandy soil from Wisconsin and North Dakota to Texas and Louisiana.

5. ALLIONIA GLABRA (S. Wats.) Kuntze, Rev. Gen. 533. 1891

Oxybaphus glaber S. Wats. Am. Nat. **7** : 301. 1873.

A rare plant from the arid districts of southern Utah, Arizona, and New Mexico.

6. **Allionia bracteata** sp. nov.

A branched, more or less viscid perennial : stem glabrous below, densely viscid-pubescent above, 4–12 dm. high, erect or ascending : leaves subsessile ; blades oblong to linear-lanceolate or linear, 3–9 cm. long, thick, mostly ciliate, glabrate : leaves of the inflorescence elliptic or oblong, to lanceolate, reduced, less than 1 cm. long, more or less viscid-pubescent : involucres often numerous in terminal cymes, 10–14 mm. wide ; lobes broadly ovate, obtuse : perianth white or pale, about 10 mm. broad : fruit oblong-obovate, 5–5.5 mm. long, prominently 8-ribbed, apiculate, constricted near the base.

This species has been mistaken for *A. linearis* and *A. albida*, but is easy distinguished by the reduced leaves of its inflorescence. It grows in dry rocky soil.

MISSOURI: Malden, 1894, *Bush, 459* (type in herb. Columbia University); Wayne, 1900, *825*; also Courtney, 1891; McDonald county, 1893, *310*.

SOUTH DAKOTA: Spring Basin, 1891, *T. A. Williams.*

ALABAMA: Selma, 1888, *McCarthy.*

7. ALLIONIA DIFFUSA Heller, Minn. Bot. Stud. **2**: 33. 1898

On dry plains, from North Dakota and Wyoming, to Kansas, New Mexico and Arizona.

8. **Allionia lanceolata** sp. nov.

A. albida Rydb. Cont. U. S. Nat. Herb. **3**: 520. 1896. Not Walt. 1788.

A branched perennial. Stems erect or ascending, glabrous below, viscid-pubescent with short hairs, 4–15 dm. high: lower leaves short-petioled, the upper sessile; blades lanceolate or ovate-lanceolate to almost linear, 3–10 cm. long, very thick, obtuse or blunt at the apex: involucres numerous, in terminal cymes, 1–1.5 cm. wide; lobes rounded ovate, sometimes acutish: perianth pink, about 10 mm. broad: fruit obovoid, 4.5–5 mm. long, with usually 4–5 broad ribs and finely tuberculate faces.

This has usually gone under the name of *Allionia albida* which it resembles in habit, but that species has white perianths and sharply acute or acuminate thin leaves. *A. albida* is confined to South Carolina and Georgia and is represented by *A. lanceolata* in the West. The latter grows in dry soil on the plains, from Minnesota and Wyoming to Tennessee and Texas.

COLORADO: Estes Park, Larimer county, *Osterhout, 1556* (type in herb. N. Y. Botanical Garden).

9. ALLIONIA LINEARIS Pursh, Fl. Am. Sept. **2**: 728. 1814

Calymenia angustifolia Nutt. Gen. **1**: 26. 1818.

Oxybaphus angustifolius Sweet, Hort. Brit. **1**: 334. 1826.

In dry soil on the plains, from Minnesota to Montana, Arizona, Mexico and Louisiana.

10. **Allionia divaricata** sp. nov.

A slender perennial. Stems usually solitary, erect, 6–10 dm. high, glabrous and shining up to the viscid-puberulent inflorescence: leaves more or less distinctly petioled, usually spreading;

blades glabrous, thickish, linear to linear-lanceolate, acute, 5–10 cm. long: involucres numerous, in terminal cymes about 1.5 cm. wide, cleft below the middle into elliptical or oval obtuse lobes: perianth pink, about 8 mm. wide: fruit oblong-obovoid, slightly compressed, bluntly angled and not strongly tubercled, strigose.

Perhaps closest related to *A. linearis*, but distinguished by the thinner divergent leaves, the form of the involucre and the fruit.

COLORADO: Durango, 1898, *Baker, Earle & Tracy, 512* (type in herb. N. Y. Bot. Garden).

ARIZONA: Bakers Butte, Mogollon Mountains, 1887, *Mearns, 253*.

11. ALLIONIA AGGREGATA (Ortega) Spreng. Syst. **1**: 384. 1825

Calyxhymenia aggregata Ortega, Nov. aut Rar. Pl. **8**: *pl. 11.* 1798 (or 1799?).

Oxybaphus aggregatus Vahl, Enum. **2**: 41, in part. 1806.

This is not the plant named *O. aggregatus* by Torrey, Watson and others, from Arizona and northern Mexico, but one that is closely related to *A. hirsuta* and generally has been confused with it. It differs mainly in the axillary solitary peduncles and in this respect is analogous to *A. Bodinii*. Vahl evidently had two plants confused, citing as synonyms *Calyxhymenia aggregata* Ortega and *Mirabilis aggregata* Cavanilles, both illustrated and closely related species of *Allionia*. Ortega's plant, which was the first published,* is densely hirsute, while Cavanilles' plant is glabrous. Vahl, in his diagnosis, describes it as glabrous but remarks in parentheses "according to Ortega hirsute."

A. aggregata grows in dry soil from Wisconsin to Texas and New Mexico, also in northern Mexico.

12. ALLIONIA DECUMBENS (Nutt.) Spreng. Syst. **1**: 384. 1825

Mirabilis aggregata Cav. Ic. **5**: 22. *pl. 437.* 1799.

Oxybaphus aggregatus Vahl, *l. c.* in part.

Calymenia decumbens Nutt. Gen. **1**: 26. 1818.

Oxybaphus decumbens Sweet, Hort. Brit. **1**: 334. 1826.

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* I have not been able to find the exact date of Ortega's fascicle in which the description appears. The ten fascicles were published in 1797–1800; but Cavanilles cites Ortega, which indicates that the latter's description was published first.

This species stands in the same relation to *A. lanceolata* as the preceding does to *A. hirsuta* and the following to *A. linearis*, differing mostly in the mode of blooming. One of the reasons for holding them as distinct species and not as forms of the species mentioned is that their ranges are different, *A. aggregata* and *A. decumbens* extending further south into Mexico and the Gulf states, while their cymose analogues are northern, and the range of *A. Bodinii* is more limited than that of *A. linearis*. *A. decumbens* grows in dry soil on the plains, from Missouri and South Dakota to Wyoming, Mexico and Mississippi.

13. ALLIONIA BODINII (Holz.) Morong, Mem. Torrey Club, **5**: 354. 1894

Oxybaphus Bodinii Holz. Contr. U. S. Nat. Herb. **1**: 287. 1893.

In dry soil from western Kansas to Utah and western Texas.

6. WEDELIA Loeff. Iter. Hisp. 180. 1758

Allionia L. Syst., Ed. 10, 890, in part. 1759.

The genus was based on a plant which the following year received the specific name *Allionia incarnata* L.

1. WEDELIA INCARNATA (L.) Kuntze, Rev. Gen. Pl. 533. 1892

Allionia incarnata L. Syst., Ed. 10, 890. 1759.

From western Texas and southern Colorado to California.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 31.

A FOSSIL PETAL AND A FOSSIL FRUIT FROM THE CRETACEOUS (DAKOTA GROUP) OF KANSAS

By ARTHUR HOLLICK

NEW YORK
1903

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 30: 102–105. 28 F 1903]

A fossil Petal and a fossil Fruit from the Cretaceous (Dakota Group) of Kansas

By Arthur Hollick

Included in a collection of fossil plant remains from the Cretaceous (Dakota Group) of Kansas, recently obtained by the New York Botanical Garden from Mr. Charles H. Sternberg, of Lawrence, Kans., are two exceedingly interesting specimens — one representing a large petal, the other a fleshy fruit.

Petals, as fossils, are exceedingly rare, and I am not acquainted with any published figure of anything of the kind which can compare with ours, in regard to either size or satisfactory condition of preservation. Unfortunately, a portion of the upper part, including the apex, is gone, but it is sufficiently perfect to indicate what was its original shape, and the principal characters of the nervation are plainly discernible.

Careful examination and comparison has shown that, in all essentials, it agrees with the petals of some of our large-flowered magnolias, such as *M. foetida* Sarg. and *M. macrophylla* Michx., and as some ten species of *Magnolia*, founded upon more or less well-defined leaves, have been described from the Dakota group, I have decided to refer it to that genus.

The probabilities, of course, are that it belongs to a species to which one of the fossil leaves belongs, but as it is impossible definitely to connect the petal with any one of these a distinctive name is necessary, which should indicate that the fossil was a petal and not a leaf.

Magnolia palaeopetala sp. nov.

Petal apparently ovate-spatulate in outline, about 15 cm. long by 10 cm. broad, convex, laterally constricted and incurved at the base; margin entire, wavy or flexuous; nervation flabellate, dictyodrome, simple and well defined below, forking and thinner above, anastomosing, the areolae and reticulations becoming successively smaller and the nervilles finer, towards the margin. (*Fig. A.*)

Locality: Ellsworth Co., Kans.

It is apparent that this petal must have possessed a texture more or less coriaceous, as otherwise its preservation in such a relatively coarse medium as the Dakota sandstone would have been impossible, and this supposition is supported by the fact that the convexity of the surface, the incurving of the base and margin and the constriction of the former, all appear to have been characters of the living flower and not to be due to subsequent distortion by fossilization.

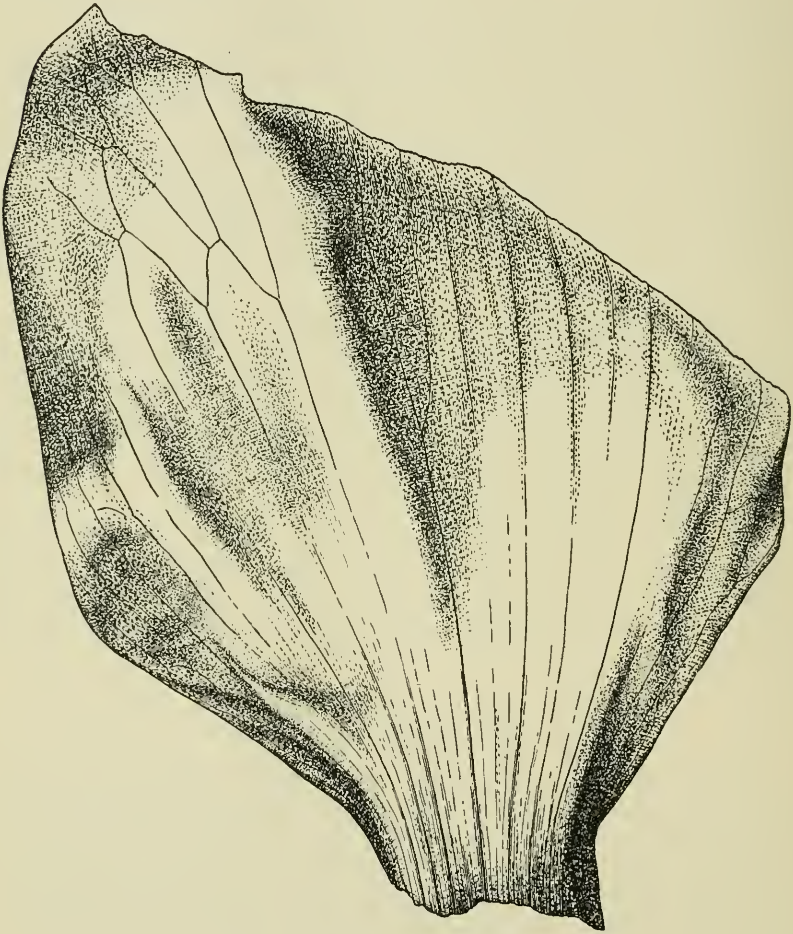

FIG. A. *Magnolia palaeopetala* Hollick.

The fruit is plainly that of a fig, and although some twenty-three species of *Ficus* have been described from the Dakota group they were based upon leaf-impressions alone. Only two specimens of fruit were known and these were too ill-defined to admit of specific description. (" Fruits of *Ficus*," Lesq. Fl. Dak. Group, 85. *pl. 10. f. 7, 8.* See our Fig. B, 2, 3.) They are incidentally mentioned however as being associated with leaves of *Ficus inaequalis* Lesq.

Specimens considerably more satisfactory were described and figured by Heer in 1874, from the lower Atane beds of Greenland — representing a geological horizon which is practically the equivalent of the Dakota group — under the name *Ficus protogaea* Heer [*] (Fl. Foss. Arct. 3^2: 108. *pl. 30. f. 5–7.* See our Fig. B, 4, 5, 6.)

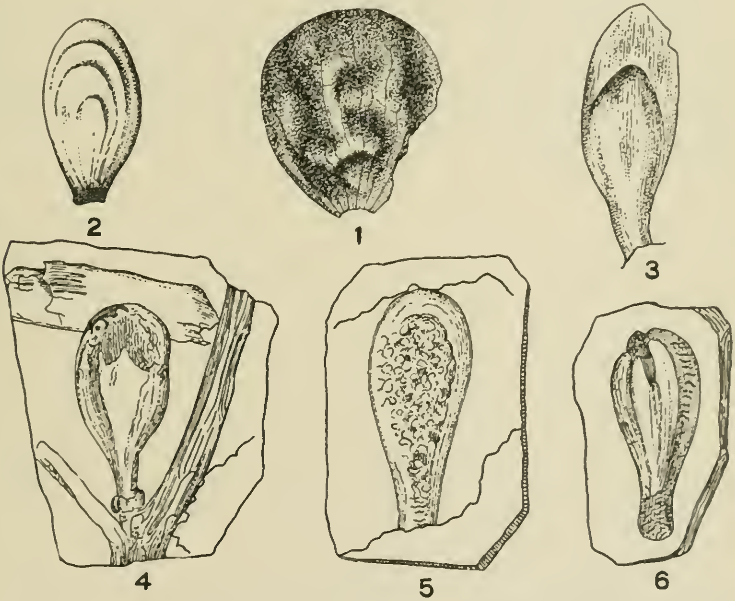

Fig. B. 1. *Ficus neurocarpa* Hollick. 2, 3. " Fruits of *Ficus* " (after Lesquereux). 4–6. *Ficus protogaea* Heer (after Heer).

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[*] The name *Ficus protogaea* was previously used by Ettingshausen, in 1867, in describing a fragmentary fossil leaf from the Cretaceous of Niederschoena in Saxony (Sitzb. Akad. Wiss. Wien, Math.-Nat. Cl. 55: 249. *pl. 2. f. 5.*) In any revision of the genus it would therefore be necessary to rename these fruits. In this paper however it is not thought necessary to do anything more than to call attention to the fact.

These five specimens are the only ones which I have found recorded as occurring in the same geological horizon as that to which our specimen belongs, or in any strata which may be regarded as its equivalent, and none of them is equal to ours as a specimen, so far as may be judged from the figures.

Ficus neurocarpa sp. nov.

Fruit broadly obovate-spatulate in outline, 2.8 cm. long by 2.4 cm. maximum width, thick and wrinkled towards the middle, flattened more or less at or near the margin, minutely punctate and delicately nerved; primary nerves convergent but distinct and separated from each other at the base, divergent and becoming thinner and indistinct above, where they anastomose; secondary nerves very fine and apparently irregularly disposed. (*Fig. B, 1.*)

Locality: Ellsworth Co., Kans.

This fossil has very much the appearance of many dried herbarium specimens and it is evident that it must have possessed considerable consistency in order to retain its original shape, as it has done to a certain extent, under the pressure to which it must have been subjected.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 32.

THE POLYPORACEAE OF NORTH AMERICA
II. THE GENUS PYROPOLYPORUS

By WILLIAM ALPHONSO MURRILL

NEW YORK
1903

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 30: 109–120. 28 F 1903]

The Polyporaceae of North America. II. The Genus Pyropolyporus *

By William Alphonso Murrill

The European species of this genus were first separated into a distinct generic group by Quélet in his "Enchiridion Fungorum" published in 1886. His genus *Phellinus* established at that time contained four species, *P. igniarius* (L.), *P. fulvus* (Scop.), *P. conchatus* (Pers.) and *P. salicinus* (Pers.), and was characterized as follows: "Pileus velvety, persisting; context corky; pores small, fulvous brown; spores ovoid, fulvous. Plants lignatile." The name *Phellinus*, however, is preoccupied by *Pheline* assigned in 1826 to a genus of the Ebenaceae. The new name *Pyropolyporus* here proposed refers to the use of some species of this group in ancient times for the purpose of keeping fire.

Synopsis of the North American Species

1. Pileus thick, ungulate, woody, margin obtuse, tubes several times stratified, the upper layers not dying before the lower. 2.
Not as above. 11.

2. Context yellowish brown. 3.
Context reddish orange; plants growing on trunks of *Juniperus*. 10.

3. Spores hyaline. 4.
Spores yellowish brown. 7.

4. Pileus becoming more or less rimose with age. 5.
Pileus covered even in age with a smooth horny crust. 6.

5. Pileus simple, sulcate, sometimes polished, margin usually narrow and rounded; not found on species of *Prunus*. 1. *P. igniarius.*
Pileus terraced, imbricate or semiresupinate, rarely sulcate, never polished, margin broad, making an obtuse angle; found on species of *Prunus*. 2. *P. fulvus.*

6. Context ferruginous, surface dark brown marked with narrow black concentric lines, tubes thin-walled, 5 to a mm. 3. *P. crustosus.*
Context tawny, surface black without lines and more sulcate, tubes smaller, thick-walled, 7 to a mm. 4. *P. Calkinsii.*

7. Pileus soon becoming rimose. 8.
Pileus not rimose, broadly sulcate, zonate, tubes thin-walled, spores 3μ in diameter, spines large and abundant; growing on *Quercus*. 5. *P. Everhartii.*

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* Read by invitation before the Botanical Society of America at Washington, January 1, 1903.

8. Tubes long, over 0.5 cm. each season, walls thin, pores large, 3 to a mm. 9.
Tubes very short, 0.1–0.5 cm. long each season, walls equalling tubes in thickness, pores small, 5 to a mm., spores globose, 4–5 μ, cystidia none; growing abundantly on *Robinia*. 6. *P. Robiniae.*

9. Spores globose, 3–4 μ in diameter, cystidia present; pileus blackish, very rimose, hymenium convex, margin truncate, at length hoary. 7. *P. praerimosus.*
Spores ellipsoidal, 7 × 9 μ, cystidia none; pileus dark brown, hymenium concave, margin not hoary. 8. *P. Underwoodii.*

10. Older pores visible in projecting annual layers, tubes 3–4 to a mm., thin-walled; pileus deeply furrowed, not rimose. 9. *P. juniperinus.*
Older pores not externally visible, tubes 1–2 to a mm., thicker walled; surface very rimose. 10. *P. Earlei.*

11. Spores hyaline. 12.
Spores yellowish brown. 15.

12. Cystidia abundant, pointed, dark brown; pileus thin, woody, rigid, tubes short, 5 to a mm. 11. *P. conchatus.*
Cystidia none. 13.

13. Context thick, woody, honey-yellow, surface encrusted, margin blunt. 12. *P. Haematoxyli.*
Context thin, punky, darker brown, surface without a crust, margin sharp. 14.

14. Pileus 10–25 cm. broad, covered with narrow shallow furrows, margin undulate or lobed, pores minute, 8–9 to a mm. 13. *P. Langloisii.*
Pileus smaller, deeply sulcate, pores larger, 6 to a mm.; growing on species of *Ribes*, very rarely on other shrubs. 14. *P. Ribis.*

15. Dissepiments thick, hymenium concolorous with context. 16.
Dissepiments thin, hymenium darker than context. 17.

16. Pileus very rimose, cystidia present; tubes fulvous, 7 to a mm., spores globose, 3.5–5 μ, cystidia 17–35 μ. 15. *P. Yucatanensis.*
Pileus scarcely rimose, encrusted, becoming smooth, cystidia absent; margin undulate, tubes 8 to a mm., spores globose. 16. *P. senex.*

17. Pileus hard and heavy, surface sulcate, brown, clothed with lime-white hair, spores 3.5 μ, spines 40–60 μ. 17. *P. linteus.*
Upper layers of pileus dead, projecting 1–2 cm. beyond the lower, tube strata separated by thin layers of context, tubes 7 to a mm., spores 5–7 μ, cystidia absent. 18. *P. Jamaicensis.*

1. Pyropolyporus igniarius (L.)

Boletus igniarius L. Sp. Pl. 1176. 1753; Tourn. Inst. 1: 562. *pl. 330. f. A.* 1719.

Polyporus igniarius Fries, Syst. 1: 375. 1821.

Fomes igniarius Gill. Champ. Fr. 1: 687. 1878; *pl. 156.*

Phellinus igniarius Quél. Ench. 172. 1886.

This plant is one of the oldest fungi known, having been used from very early times for keeping fire, whence the name. It is also abundant and widely distributed, occurring on birch, willow, beech, maple, oak, poplar, apple and many other deciduous trees in various parts of the world. Fruit-bodies observed on apple, willow, aspen, birch, etc., in Sweden, agree perfectly with those growing in the New York forests; while the variations found in Europe are duplicated here, even to the abundance or scarcity of spines in the hymenium.

Specimens are to be found in all published exsiccati bearing upon this group. Among the large number of collections examined, the following may be mentioned: New York (Underwood), New Hampshire (Miss Minns), Ottawa, Canada (Macoun), New Jersey (Ellis), Virginia (Murrill), Kansas (Bartholomew), Indiana (Underwood), Colorado (Earle), Labrador (Waghorne), Maine (Ricker), New Mexico (Earle), Finland (Karsten), Sweden (Murrill), Thüringen (Underwood).

Two forms of *P. igniarius* are listed as distinct species in Saccardo's Sylloge, *i. e.*, *Fomes badius* Berk. and *Fomes nigricans* Fries. The former was collected in Arctic North America by Dr. Richardson and the type is at Kew. The specimen is 5 × 6 × 2.5 cm. and has three layers of tubes which, in the brief northern season, were forced to develop quickly and are therefore thinner-walled than in our forms. Berkeley himself doubted if the plants were sufficiently distinct from *P. igniarius*.

Fomes nigricans Fries, on the other hand, is decidedly different from typical *P. igniarius*, being neat and smooth and shining black, and rimose in two directions when old. Fries observed it on birch only. Persoon noticed it also frequently on old willows, and Underwood has collected fine specimens of the same form on beech in the New York mountains. While studying living plants on willow trees in Sweden, I found stages on the same tree connecting this variety with the typical form and am convinced that we are not here dealing with two distinct plants but with variations due to season, food supply, rapidity of growth, or some other physiological cause yet to be determined. Specimens have been examined from Finland (Karsten, Starbäck), Sweden (Romell, Murrill), Newfoundland (Waghorne), Greenland (Rostrup), New

Hampshire (Miss Minns) and New York (Underwood). Klotsch's collections from Scotland are *Polyporus fomentarius* L. of advanced age and indurated. This is the conception of *F. nigricans* at Berlin (see Sydow, Myc. Mar. No. 2604). At Kew, *F. nigricans* has been considered "rare the world over." A tiny specimen 2 × 3 × 2 cm. in the herbarium of Berkeley sent from Upsala presumably by Fries himself has the external appearance of *F. nigricans* (see Fries, Icon. *pl. 184*), but its size would indicate that it is *Poria levigata* Fries, in its pileate form, a state of this fungus not known to Fries and easily confused with depauperate forms of *F. nigricans.* The other specimens at Kew are all old hardened forms of *P. fomentarius* L.

2. **Pyropolyporus fulvus** (Scop.)

Boletus fulvus Scop. Fl. Carn. Ed. 2. **2**: 469. 1772.

Polyporus igniarius b. minor, subperpendicularis Fries, Syst. **1**: 375. 1821.

Polyporus fulvus Fries, Hym. Eur. 559; Icon. *pl. 184, f. 3.*

Fomes fulvus Gill. Champ. Fr. **1**: 687. 1878.

Phellinus fulvus Quél. Ench. Fung. 172. 1886.

Fries at first considered *Boletus pomaceus* Pers. synonymous with *B. fulvus* Scop., but later decided, and correctly so, that it is only a form of *P. igniarius* L. In Micheli's no. 9, p. 119, of his genus *Agaricum*, the two forms are confused, though his figure, *pl. 61*, ordo II, doubtless represents *P. fulvus* growing on *Prunus* and not *P. igniarius* growing on *Malus.* This confusion still exists in European herbaria and it is impossible to determine in them what is meant by *Polyporus fulvus* Fries. In the following description Scopoli very plainly characterizes the plant under discussion: "Totus fulvus; poris difformibus, non adeo profundis. Habitat in cerasis recens detruncatis. Junior integerrimus, adultus vero margine sinuatus. Fulvus color in margine et subtus evidentior. Poruli obsoleti, totum fungum subtus non semper occupant."

Pl. Crypt. France par Desmazières no. 5157. "Sur les pruniers et les cerisiers." Fung. Selec. Exsic. par Roumeguère No. 6963. "Forma *Cerasi*, sur un vieux cerisier." Trienti (Bresadola) on *Persica*, Eisenach and Thuringen (Underwood) on *Prunus*, Sweden (Murrill) on *Prunus,* and on *Prunus* both wild and cultivated, in America in Alabama (Underwood), Colorado (Bethel, Cameron, Crandall), Kansas (Bartholomew, Cragin), Missouri (?), Nebraska (Webber), Ohio (Lloyd), Tennessee (Schrenk).

This fungus is very uniform in habit and appearance both in Europe and America, where it occurs on various species of *Prunus* and its near allies. Although confused in literature with *Polyporus igniarius* L., it is very distinct and always easily recognized. In an orchard near Mauritzberg, Sweden, where *P. igniarius* was abundant on apple trees, *P. fulvus* was confined to the stumps and dead or dying trunks and branches of plum trees.

3. **Pyropolyporus crustosus** sp. nov.

An ungulate plant of medium size with brown tubes, ferruginous substance and smooth encrusted dark brown surface. Pileus woody, convex above, plane below, somewhat compressed ungulate, 7 × 12 × 5 cm.; surface glabrous, horny encrusted, dark brown, concentrically sulcate, marked with narrow black concentric lines; margin rounded, yellowish brown, sterile: context hard, concentrically banded, ferruginous, 2 cm. thick behind; tubes indistinctly stratified, 0.5–1 cm. long each season, 5–6 to a mm., drab-colored within, mouths polygonal, concolorous, edges thin, acute, entire: spores globose to ovoid, smooth, thin-walled, hyaline, 3.5–4 × 4 μ, hyphae darker, cystidia none.

Collected by Earle on a standing tree trunk at an altitude of 4,000 feet on Rose Hill, Jamaica, October, 1902.

4. **Pyropolyporus Calkinsii** sp. nov.

A large ungulate fungus glabrous and furrowed above and uniformly hard and fulvous within. Pileus very hard woody throughout, ungulate, 10 × 10 × 10 cm.; surface glabrous, dark brown to black, marked with rather shallow concentric furrows, crust thin, horny, never rimose; margin rounded, concolorous with the hymenium: context very hard woody, fulvous, 1 cm. thick; tubes in many indistinct layers, slender, minute, 7 to a mm., fulvous, mouths nearly circular, obtuse, entire: spores ovoid, hyaline, with thick, smooth, pale ferruginous wall, 3–5 × 5–7 μ, hyphae ferruginous, cystidia none.

This species occurs on living trees of live-oak in Florida, where it was collected in considerable quantity by Major W. W. Calkins during the winters of 1886 and 1887. Several specimens are in the herbarium of the New York Botanical Garden and a single specimen in the herbarium of the Division of Vegetable Pathology and Physiology of the U. S. Department of Agriculture.

5. **Pyropolyporus Everhartii** (Ell. & Gall.)

Mucronoporus Everhartii Ell. & Gall. Journ. Myc. **5**: 141–142. *pl. 12.* 1889.

Xanthochrous Everhartii Pat. Cat. Tun. 51. 1897.

The type of this fungus is in the herbarium of the New York Botanical Garden. Since its discovery on the living trunk of a scarlet oak in New Jersey, it has been collected in several localities on various species of oak and occasionally on beech. Before its separation as a distinct species it had been confused with *P. igniarius*, which it outwardly resembles in some particulars.

Collections: New York (Ellis, Mrs. Ellis, Murrill), New Jersey (Ellis, Ely), Canada (Dearness), Indiana (Gentry), Pennsylvania (Herbst) and Delaware (Commons, Ellis N. A. Fungi no. 3303).

6. **Pyropolyporus Robiniae** sp. nov.

A large fungus with dark rimose surface and tawny hymenium very common on *Robinia pseudacacia.* Pileus hard woody, dimidiate, ungulate to applanate, 5–25 × 5–50 × 2–12 cm.; surface velvety, smooth, soon becoming very rimose and roughened, fulvous to purplish-black, at length dull black, deeply and broadly concentrically sulcate; margin rounded, velvety, fulvous: context hard woody, concentrically banded, 1–3 cm. thick, fulvous; tubes stratose, 0.15–0.5 cm. long, 5 to a mm., fulvous, mouths subcircular, dissepiments entire, equalling tubes in thickness: spores subglobose, smooth, thin-walled, ferruginous, copious, 4–5 μ, cystidia none.

This fungus was one of the first to be noticed by collectors in this country, but has been unnamed until the present time. Schweinitz called it *Polyporus igniarius* and remarked that it was "frequent especially on *Robinia*"; Berkeley confused it with his *P. rimosus* described from Demerara and the Cape of Good Hope, and Cooke allayed Morgan's anxiety by assigning it most positively to the same category. To be sure, it resembles *P. rimosus* Berk. from Demerara, but the two plants are entirely distinct in appearance and shape and *P. rimosus* lacks the decided imbricated-rimose effect so characteristic of our plant. It was from the African plant, a different thing from *P. rimosus*, that the name *rimosus* must have been obtained. It is truly rimose like *R. Robiniae*, but differs decidedly from the latter in pore-structure and context, while the spores are larger and less globose. It would be quite remarkable if a group of plants from such widely separated localities did not show specific differences.

P. Robiniae is abundant in the southern United States on *Robinia* and extends with it as far north as Connecticut and west to Missouri and Texas. I have not as yet seen it upon any other host, but a plant recently collected by Earle in Jamaica on *Acacia emarginata*, nearly related to *Robinia*, seems not specifically distinct from it. When *Robinia* was introduced into France several centuries ago from Virginia this fungus must have been introduced with it, since it was collected there by F. Fautrey in November, 1891, growing on *Robinia*. The specimen is at Upsala and is labelled *P. igniarius*. Among the many collections examined from America, the following may be mentioned: Massachusetts (Underwood); New York (Underwood, Earle, Murrill); New Jersey (Ellis); Ohio (James, Morgan, Lloyd); West Virginia (Nuttall); Virginia (Miss V. W. Murrill); Alabama (Underwood, Atkinson, Earle).

A good account of the destructive effects of this plant is given by H. von Schrenk in Ann. Rep. Mo. Bot. Gard. **12**: 21–31. *pl. 1–3*. 1901.

7. **Pyropolyporus praerimosus** sp. nov.

A large ungulate plant with plane brown hymenium and a very rimose blackish surface. Pileus woody, rounded ungulate, 8–12 × 7–10 × 8–11 cm.; surface exceedingly rimose after the first year, broadly furrowed, the projecting ridges splitting away in age, very dark brown to black; margin obtuse, velvety, rusty to hoary: context corky to woody, concentrically banded, fulvous, 0.5 cm. or less thick; tubes indistinctly stratified, 1–2 cm. long each season, 3 to a mm., concolorous within and without with the context, mouths rounded to polygonal, ochraceous at first, edges rather thick, obtuse, becoming thin and often splitting in age: spores globose, smooth, deep ferruginous, 3–4 μ; spines ferruginous, 10–17 × 5–10 μ, largest at the base.

Collected by Earle, July, 1900, on *Quercus undulata* in the El Capitan Mountains, New Mexico, at an altitude of 7,000 feet. Related to *P. Everhartii* (Ell. & Gall.).

8. **Pyropolyporus Underwoodii** sp. nov.

A blackish ungulate plant of large size with furrowed rimose surface and long brown tubes. Pileus woody, broadly ungulate, attached by a narrow base, concave below, 7 × 14 × 11 cm.; surface many times concentrically furrowed, rimose, uniformly dark-brown to black; margin fulvous, acute or somewhat obtuse, velvety, undulate, marked with narrow zones: context hard, fulvous to dark brown, very thin, less than 0.5 cm.; tubes distinctly stratified, 0.5–1.5 cm. long each season, 3 to a mm., brown within, mouths darker, circular or polygonal, edges acute, entire: spores ellipsoidal, smooth, thin-walled, light yellowish-brown, $7 \times 9 \mu$, cystidia none.

Collected by Underwood and Griggs during the summer of 1901 near Coamo Springs, Porto Rico. The plant reminds one of *P. Robiniae*, but differs very widely in tube-structure, as well as in color, density and spore characters.

9. **Pyropolyporus juniperinus** (Schrenk)

Polyporus juniperinus Schrenk, U. S. Dept. Agr. Veg. Physiol. Bull. **21**: 9–16. *pl. 1–4.* 1900.

So far as I know, there are only two specimens of the fruiting stage of this plant in existence, one collected by Schrenk in Tennessee and the other by Miss Sadie F. Price in Kentucky. The latter specimen, the better developed of the two, was sent to the Underwood herbarium in 1895.

Both specimens were found upon *Juniperus Virginiana*, the wood of which is badly affected by its mycelium. The statement made by the author that the discovery of other specimens might prove this species to be only a form of *P. fomentarius* is entirely unnecessary, since such connection between two plants so distinct is beyond the range of possibility.

10. **Pyropolyporus Earlei** sp. nov.

A broadly ungulate plant with yellow pores, red context and a dark very rimose surface. Pileus woody, attached by a broad base, plane below, 6 × 13 × 17 cm.; surface concentrically sulcate, very rimose in older parts, fulvous to brownish-black, at length grayish-black from weathering; margin broad, obtuse, dark yellowish-orange, clothed with short dense tomentum of the same color: context woody, dark reddish-orange, concentrically banded with darker lines, very thin, 0.5 cm., rimose down to the tubes; tubes unevenly stratified, 0.5–0.75 cm. long each season, 1–2 to a mm., ochraceous within during the first season, afterwards latericeous, mouths circular, ochraceous, edges obtuse, rather thin: spores ellipsoidal, smooth, thick-walled, ferruginous, 7–8 × 9 μ.

Collected by Earle in August, 1900, on a standing trunk of *Juniperus* in the El Capitan Mountains, New Mexico, at an attitude of 7,000 ft. It is closely related to *P. juniperinus* (Schrenk), but it is much more rimose, has larger pores and lacks the annual projecting margins of the older tube-layers so characteristic of that species.

11. **Pyropolyporus conchatus** (Pers.)

Boletus salicinus Pers.; Gmel. Syst. **2**: 1437. 1791; Syn. 543. 1801. Not *B. salicinus* Bull. Herb. Fr. *pl. 433. f. 1.* 1789.

Boletus conchatus Pers. Obs. **1**: 24. 1796; Syn. 538. 1801.

Polyporus salicinus Fries, Syst. Myc. **1**: 376. 1821; Icon. *pl. 185. f. 2.*

Polyporus conchatus Fries, Syst. Myc. **1**: 376. 1821.

Fomes salicinus Gill. Champ. Fr. **1**: 684. 1878; Karst. Icon. 4, *f. 5.* 1883.

Phellinus salicinus Quél. Ench. 172. 1886.

Boletus salicinus Pers. and *Boletus conchatus* Pers. were different forms of the same plant. Most of the old willow stumps in Sweden are covered with it. On the sides of the stumps it is *B. salicinus* and farther up, where the pileus is reflexed, it is *B. conchatus.* This fungus is quite common in Europe and America on a variety of hosts. The following list includes only a few of the collections examined: Sydow, Myc. Mar. no. 3423; Ellis, N. A. Fungi no. 918; Romell, Fungi Suecici no. 12; England (Plowright), Sweden (Murrill), New York (Underwood, Ellis, Shear), Indiana (Underwood), Canada (Macoun), Ohio (Lloyd, Morgan), Pennsylvania (Rau).

12. **Pyropolyporus Haematoxyli** sp. nov.

A smooth applanate plant of considerable size with brownish tubes and honey-yellow context. Pileus woody, dimidiate, sessile, thickest behind, 12 × 14 × 4 cm.; surface glabrous, dark brown, shallowly concentrically sulcate, marked with numerous darker concentric lines; margin fulvous, thin, rounded, slightly undulate: context corky to woody, indistinctly concentrically banded, honey-yellow, 1 cm. thick; tubes distinctly stratified, longer behind, 0.5–1 cm. long each season, 6 to a mm., dull brown, mouths polygonal, concolorous, edges obtuse, becoming thin; spores globose, rarely ovoid, thin-walled, smooth, hyaline, 3.5–5 μ, hyphae ferruginous, cystidia none.

Collected by Earle at the base of a living logwood tree in Paradise, Jamaica, November, 1902.

13. **Pyropolyporus Langloisii** sp. nov.

A large thin expanded fungus with brown hymenium and a brown or blackish surface. Pileus corky, fan-shaped, attached by a narrow base, often depressed behind, 8–13 × 10–25 × 0.3–1.5 cm.; surface at first anoderm, soft, clothed with brown tomentum, many times concentrically sulcate, at length glabrous, rough, indurate, black, marked with numerous shallow furrows; margin velvety, brown, thin, acute, undulate or slightly lobed: context soft to corky, indurate in age, deep brown, 0.2–0.5 cm. thick; tubes reviving, distinctly stratified, 0.2–0.5 cm. long each season, 9–8 to a mm., brown, mouths polygonal, concolorous, edges thin at maturity: spores globose, smooth, hyaline, 3 μ, cystidia none.

Collected in quantity several seasons in Louisiana by Langlois, exclusively on dead or dying hawthorn trees near the base of the trunk. Referred to *P. pectinatus* Kl., *P. senex* N. & M., *P. conchatus* Pers., and *P. Ribis* (Schum.) Fries by European mycologists, from all of which it is quite distinct, probably approaching nearest to the last. Several specimens from the various collections made by Langlois are in the Underwood herbarium and the herbarium of the New York Botanical Garden.

14. **Pyropolyporus Ribis** (Schum.)

Boletus Ribis Schum. Enum. Pl. Saell. **2**: 336. 1803.
Polyporus Ribis Fries, Syst. **1**: 375. 1821.
Polyporus ribesius Pers. Myc. Eur. **2**: 80. 1825.
Polyporus Ribis Fries; Sturm, Deuts. Fl. **3**: 137. *pl. 62.* 1837.
Fomes Ribis Gill. Champ. Fr. **1**: 685. 1878.

According to some authorities *P. Lonicerae* Weinm. and *P. Euonymi* Kalchb. are only forms of the above. Rabenhorst-Winter, Fungi Europaei, no. 2937; Roumeguère, Fungi Gallici, no. 3304; De Thümen, Myc. Univ., no. 509; Linhart, Fungi

Hung., no. 349; Krieger, Fungi Sax., no. 423; New York (Ellis); New Jersey (Geissman, Ell. & Ev. N. A. Fungi no. 1693); Kansas (Bartholomew).

The usual host of this fungus is the red currant, but it is also found on other species of *Ribes* and occasionally upon other shrubs growing near by. Specimens from Bartholomew were collected on living stems of *Symphoricarpos occidentalis*, July 24, 1895; and it has also been reported as attacking rose-bushes.

15. **Pyropolyporus Yucatanensis** sp. nov.

A large blackish brown very rimose fungus with tawny tubes and substance. Pileus woody, dimidiate, applanate, thickest behind, 7–9 × 9–12 × 2–3 cm.; surface clothed at first with tawny tomentum, becoming very dark brown or black and uniformly tubercular and broken into small areas by numerous shallow concentric furrows and radial cracks; margin narrow, acute, velvety, fulvous: context hard, fulvous, 0.5 cm. thick; tubes rather indistinctly stratified, 0.25 cm. long each season, 7 to a mm., fulvous; mouths circular, punctate, edges thick, obtuse: spores globose or subglobose, smooth, pale yellowish brown, 3.5–5 μ, hyphae ferruginous, cystidia thick at the base, pointed, 17–35 μ.

Collected in Yucatan by Millspaugh and in Nicaragua by C. L. Smith.

16. **Pyropolyporus senex** (Nees & Mont.)

Polyporus senex Nees & Mont. Ann. Sci. Nat. II. **5**: 70–71. 1836.

Fomes senex Cooke, Grevillea, **13**: 118. 1885.

A number of specimens collected by C. L. Smith in Mexico and Nicaragua are in the New York Botanical Garden herbarium. Dr. Patouillard says they are typical *P. senex*. They are larger, thicker and more woody than plants from Florida and Louisiana that have been called *P. senex*.

17. **Pyropolyporus linteus** (B. & C.)

Polyporus linteus B. & C. Proc. Am. Acad. Arts & Sci. **4**: 122. 1860.

Fomes linteus Cooke, Grevillea, **14**: 20. 1885.

The type specimens were collected on dead bark in Nicaragua. Plants collected in Nicaragua by C. L. Smith agree with the types in all important particulars. The same species from Cuba is labelled *P. pectinatus* Kl. at Kew, though the latter plant does not, to my knowledge, occur in North America.

18. **Pyropolyporus Jamaicensis** sp. nov.

A rather small fan-shaped plant, the upper layers of which are dead and much cracked and roughened while the layers added below are smaller each succeeding year. Pileus woody, applanate, much thicker behind, 8 × 13 × 0.5–5 cm.; surface uneven, radiately rimose, dark brown to black; margin ferruginous, velvety, acute, becoming black, spreading and lobed, projecting 1–2 cm. beyond the new layers: context woody, fulvous, 0.5–1 cm. thick; tubes stratified, separated by thin annual layers of context, 0.2–0.7 cm. long each season, 7 to a mm., fulvous within, mouths rounded or polygonal, hoary when young, edges thin, acute, entire: spores globose or subglobose, thin-walled, smooth, pale golden-yellow (probably darker in age), 5–7 μ.

Collected by Earle, at Port Antonio, Jamaica, November, 1902, on an old stump of *Psidium*. The spores of the present season appear immature.

SPECIES INQUIRENDAE

In this list is included not only species at present unknown, but also plants described by foreign authors which have not been seen or have been as yet only slightly studied by the writer. *Polyporus extensus* Lév., *P. elatus* Lév., *P. Nicaraguensis* B. & C., *P. sarcitus* Fries, *P. sclerodes* Berk., *P. scleromyces* B. & C., *P. sordidus* Lév., *P. subflexibilis* B. & C., *P. Baccharidis* Pat., *Ganoderma Mexicanum* Pat., *Xanthochrous igniarioides* Pat.

NEW YORK CITY.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 33.

STUDIES IN THE ASCLEPIADACEAE—IV.-VII.

By ANNA MURRAY VAIL

NEW YORK

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Studies in the Asclepiadaceae.—IV

BY ANNA MURRAY VAIL

I. NOTES ON SOME OLD TYPES, WITH DESCRIPTIONS OF NEW OR LITTLE KNOWN SPECIES

ASCLEPIAS SCAPOSA Vail, Bull. Torr. Bot. Club, 25: 171. 1898

On a specimen of this species in Wright's New Mexican collection, no. 1683 in part, preserved in the Herbarium of the British Museum, I was fortunate to find a somewhat mature but complete flower, which through the courtesy of Mr. James Britten I was permitted to examine closely, so that to my former description I am able to add the following:

Corolla-segments 5 mm. long, apparently white; column short and broad; hoods of the corona barely exceeding the anthers, 2–2.5 mm. high, white or whitish, slightly pendulous or saccate at base, 5-dentate at the apex; central tooth rounded, the intermediate teeth acutish, the two ventral ones infolded, erect, slender, attenuated, nearly twice as long; horn arising from about the middle of the hood, slender, exserted; anther-wings salient and somewhat rounded at the base, apparently entire.

In floral structure allied to *A. quinquedentata* Gray and to *A. Palmeri* Vail, but its low habit and solitary terminal peduncle are, with few exceptions, rather unusual in the genus. I have seen only four specimens of it, the one in the Herbarium of Columbia University (Wright, no. 1684 in part), a fragment in Herb. Gray from the same collection (no. 1683 in part), the specimen mentioned above, and the one referred to below. In the first three cases it has been distributed with *A. longicornu* Benth. and *A. parviflora* Willd. (*A. perennis parvula* Gray). The fourth specimen is in the Herbarium of the Missouri Botanic Garden and is on a sheet with a specimen of (probably) *A. longicornu* Benth. in fruit only, the label bearing the following inscription: "No. 7, *Ascl. longicornu*, Wright, 1851."

Asclepias parvula (A. Gray)

Asclepias parvifolia Willd.? Torr. Mex. Bound. Surv. 164. 1859. Not Ait. 1789.

Asclepias perennis var. *parvula* (A. Gray) Proc. Am. Acad. **12**: 70. 1876.

Asclepias nivea Hemsl. Biol. Centr. Am. **2**: 325 and **4**: 69. 1881–2. Not Linn. 1753.

Pale gray-green throughout. Stem woody at the base, 3 dm. high, or more, erect, pubescent, often branched above: leaves short-petioled; blades lanceolate or oblong-lanceolate, tapering at each end, 4–6 cm. long, rather thick and coriaceous, glabrous or minutely puberulent above, puberulent beneath on the veins and revolute margins: peduncles 3–9, terminal and lateral, 1–4 cm. long; umbels 10–20-flowered: corolla white, small; column slender; hoods hastately sagittate at the base, not exceeding the anthers; horn falcate, thin, exserted, inflexed over the anthers: anther-wings narrow, entire at the salient base: follicles slender-fusiform, tapering to each end, 7–9 cm. long, glabrous: seeds 7 mm. long, red-brown, very thin, glabrous; coma 2–3 cm. long, abundant.

Mexican Boundary Survey, Head of Rock Creek, Bigelow, July 7, 1852; "*New Mexico*," Wright; *Texas:* Havard, Neally; *Mexico:* Palmer, no. 812.

The Wright specimen [no. 1684 in part] enumerated here is in the Herbarium of Columbia University. No. 1683, also of Wright's collection, contains besides *A. parvula* some specimens of *A. longicornu* Benth. (the plant since described as *Podostemma Emoryi* Greene, Pitt. **3**: 237), and some specimens of *A. scaposa* Vail.

Stelmagonum ? Holtonii

A low perennial herb. Root slender, vertical: stems slender, twining above, granular-puberulent and thinly hirsute with stiff spreading hairs, the lower portion with small corky-barked ridges: leaves opposite, on slender, granulose-puberulent and hirsute, 1.5–2.5 cm. long petioles; blades ovate-cordate, 3–4 cm. long, 1.5–2 cm. wide, acuminate at the apex, basal lobes rounded with narrow open sinus, granular-puberulent and with a few scattered short stiff hairs above, granular-puberulent and with more numerous stiff hairs beneath, especially on the veins, margins ciliate: flowers 4–7 in short-peduncled bracteolate cymes: peduncles axillary, 3 cm. long; pedicels 4–5 mm. long, the bracteoles subulate, very small, persistent: calyx 5-parted to below the middle, 2–3 mm. long, granular-puberulent and ciliate; segments acuminate, with an erect subulate gland in each sinus: corolla campanulate, 7–8 mm. long ? or more, 5-parted to a little below the middle, minutely granular-puberulent on the outer surface; segments oblong, obtuse, glabrous within; crown cohering to the corolla and to the raised gynostegium, cup-shaped, 5-lobed, each lobe abruptly contracted into a slender, linear 1 mm. long, erect ligule: stigma rounded, scarcely depressed: pollinia orbicular, horizontal or ascending on rather broad, winged caudicles; corpuscle nearly rhombic. Follicles not seen.

New Grenada: Goudot; Flora Neogranadina-Magdalena, I. F. Holton, Opia, no. 461, Dec., 1852.

Both of these specimens are in the Kew Herbarium and a duplicate of the Holton number is in the Herbarium of Columbia University.

Mellichampia ligulata (Benth.)

Enslenia ligulata Benth. Pl. Hartw. 290. 1848.

Mellichampia rubescens A. Gray; S. Wats. Proc. Am. Acad. **22**: 437. 1887.

For some time past I have suspected the identity of *Mellichampia* with *Enslenia ligulata* and through the courtesy of the Director of the Royal Gardens at Kew, I have obtained a tracing of the type of the latter plant which confirms the suspicion. Besides the type from Aguas Calientes, South Mexico, it has been collected in the State of Jalisco, at Guadalajara, by Dr. Palmer, no. 280, July–October, 1886, and by C. G. Pringle, in copses near Guadalajara, no. 5432, Aug., 1893. Mr. Hemsley (Biol. Centr. Am. **2**: 358) also quotes a specimen without locality from Herb. Pavon as belonging to this species. The specimens distributed as *Enslenia ligulata* by Pringle (no. 4494) and *Ampelamus ligulata* by A. A. Heller (no. 1899) are species of *Roulinia*.

II. THE TYPES OF GONOLOBUS MICHAUX AND DESCRIPTIONS OF NEW SPECIES IN VINCETOXICUM WALTER

The types of the three species of *Gonolobus* (Michx. Fl. Bor. Am. **1**: 119) are preserved in the Herbarium of the Museum in the Jardin des Plantes, Paris, where they are represented by several specimens each, all in a somewhat fragmentary condition, though quite recognizable and agreeing with the descriptions. In the Richard Herbarium (Herbarium of M. Drake del Castillo, Paris) the actual specimens owned and described by Richard in the Fl. Bor. Am. can be seen and they are in every way exact duplicates of the plants in the Michaux Herbarium proper, but are apparently more carefully labeled and named than those in the Museum. These last were annotated by Dr. Gray. The first sheet there has as inscription "*Cynanchum macrophyllum capsulis angulosis*" and is apparently the plant previously named *Vincetoxicum gonocarpos* Walt. and the plant which Dr. Gray (Proc. Am. Acad. **12**: 75) recognized as *Gonolobus laevis* var. *macrophyllus*. The specimen in the Richard Herbarium has the name "*G. macrophyllus*" and habitat "*In silvis Caroliniae*" on the sheet and is the same plant as the one in the Herb. Michaux.

The second species, *Gonolobus hirsutus*, is more difficult of determination as of course I was not able to make a dissection of the flower and the species is not so readily recognized as the first. There are muricate follicles in both collections and in Herb. Richard two racemes, one dark purple and the other very faded, dull greenish and shrunken; the leaves are large and the plant could be referred as readily to *G. Carolinensis* as to *G. hirsutus*. It is apparently identical with the plants that have been named *G. hirsutus* var. *flavidulus*. (See plants collected by Dr. Mellichamp at Bluffton, S.C., and so named by Dr. Gray). Since seeing these types, I have examined a long series of the *G. hirsutus* and var. *flavidulus* and also *G. Carolinensis* and have come to the conclusion that it will take very critical study and much more material, especially fresh material, to determine whether there are really two species there or only one. The coronal characters are difficult to reach in the dried plants and in the specimens which have passed through my hands I have found every form of crenation, both regular and irregular and great variation in the thickness of the crown-margin and also numerous instances in which the thickened alternate crenations have a very pronounced horn-like process within. Sometimes these last characters showed themselves in all stages of development from a faint obscure ridge near the apex of the crown-segment to a sharply incurved tooth. These again were to be found on one or two of the segments and again on every one of them. So far as I have been able to note, these characters are constant on the same plant. In some specimens the crown is uniformly thin, entirely lacking the alternate thickened divisions of the descriptions, others again have the thin geminate teeth claimed for *G. Carolinensis* and the quadrate alternate divisions belonging to *G. hirsutus.* It seemed entirely impossible with the material at hand to draw any fast or hard line between them. The pollinia that have very marked characters in the other species seem to be about the same in these two species and I could not find any differences between those of the flowers labeled *G. hirsutus* and of those called *G. Carolinensis.*

These two Michauxian species constituted the older genus *Vincetoxicum* of Walter which leaves the third species *G. laevis* as the type of the genus *Gonolobus.*

The type of *Gonolobus laevis* is somewhat of a curiosity. There is quite a good deal of it, small pieces mostly, but all of the specimens in the two collections agree and point unmistakably to the plant since called *Enslenia albida* Nutt. (*Ampelanus albida* Britt., Bull. Torr. Bot. Club, **21**: 314). In the Michaux Herbarium there are on a sheet a small specimen of *G. suberosus?* (the name and query are in Dr. Gray's* handwriting), one angled follicle and one raceme, noted as *G. laevis*, also by Dr. Gray, and two more leaves and two follicles. The old labels read "*Cynanchum capsulis laevis*" and "*Gonolobus laevis, Illinois.*" In the Richard Herbarium the specimens, consisting of some leaves and one angled follicle, are much worm-eaten. They are all, except the fragment of *G. suberosus*, *Enslenia albida.* This will clear up the discrepancy of the original description of *G. laevis* with the plants that have passed as such. "*Foliis quasi conoideo-cordatis, sensim acutis nervis tantum minutissime puberulis*" describes certainly the leaves of *Enslenia albida*, but scarcely accurately those of the so-called *Gonolobus laevis.* The synonymy of this plant should therefore be as follows:

GONOLOBUS LAEVIS Michx. Fl. Bor. Am. **1**: 119. 1803

Enslenia albida Nutt. Gen. Am. **1**: 164. 1818.

Ampelanus albidus Britton, Bull. Torr. Bot. Club, **21**: 314. 1894.

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* *Gonolobus suberosus* and *G. macrophyllus* are very close in general appearance, though the former has commonly yellowish-green leaves, with truncate base, and the latter darker green leaves that have notably large rounded basal and often overlapping lobes.

The type of this species is from Illinois, where it is not infrequently met with on river-banks and in thickets. It has a wide range, eastward and southward. The specimen quoted from Washington, D. C., as *Vincetoxicum gonocarpos laevis* in Britton & Brown, Illustrated Flora, **3**: 18, is in fruit and is the true *Gonolobus laevis* Michx. (Herb. Columbia University).

A second species **Gonolobus volubilis** (*Nematuris volubilis* Turcz. Bull. Soc. Nat. Imp. Mosc. **21**: 254. 1848. *Enslenia volubilis* Karst. Fl. Columb. **2**: 117. Pl. 162. 1866) occurs near Pt. Cabello, U. S. of Colombia.

VINCETOXICUM SUBEROSUM (L.) Britt., Mem. Torr. Bot. Club, **5**: 266. 1894.

Cynanchum suberosum L. Sp. Pl. 212. 1753. Dill. Hort. Elth. 300. *pl. 229. f. 296*, excluding Hort. Cliff. and Gron. 27.

Gonolobus suberosus R. Br. Ait. Hort. Kew. ed. 2, 82. 1811.

Dr. Gray * has written the history of this species and in addition to his notes it may be of interest to point out that the plant "*Apocynum scandens fruticosum fungoso cortice Brasilianum.*" Herm. Parad. 53 is probably the plant since referred to *Ibatia*, and is not the specimen of the Hortus Cliffortianus which resembles it only as to the corky, ridged bark of the stems. The Cliffort plant can be seen in the Herbarium of the British Museum and is difficult to identify as it is a mere fragment, but the character of the stem should make it easily recognizable were there more available material of the same species for comparison.

I venture to describe the following species as new.

Vincetoxicum Floridanum.

Puberulent throughout. Stems very slender, hirsute with few short, scattered hairs: leaves opposite; petioles 5–20 mm. long, angled; blades ovate, 2–5 cm. long, cordate, tapering to the acuminate apex, the basal lobes rounded, with open sinus, about equally puberulent with a fine soft pubescence on both surfaces; midvein obscurely bi-glandulose at the base above: racemes about the length of the petioles; pedicels 12 mm. long: calyx very small; segments 2 mm. long, linear-lanceolate, with a subulate gland in each sinus: corolla dull greenish-purple, 5-parted to a little below the

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* Proc. Am. Acad. **12**: 75. 1876.

middle; segments linear-lanceolate, acute, 3–5 m. long, somewhat fleshy, minutely puberulent, on the outer surface, glabrous within; crown red-purple, saucer-shaped, with 5 broad undulations each bidentate at the callous thickened apex, and a smaller tooth on each side below the middle: stigma depressed, not 5-angled: pollinia oblong, the caudicles broad and apparently not twisted? Follicles not seen.

East Florida: Dr. Leavenworth.

The specimen from which this description has been drawn is in the Herbarium of Columbia University and was labeled by Dr. Torrey, *Gonolobus* "*macrophyllus*." It was seen by Dr. Gray when he was working on the Asclepiadaceae for the Synoptical Flora and bears his note to the effect that it has "short denticulate lobes" and on the Synoptical Flora label the doubtful one of "seemingly *Gonolobus Carolinensis*." It differs however from that species, as elsewhere ticketed by Dr. Gray in its much smaller, greenish flowers, and the crown which has not the regular divisions of that of *Vincetoxicum Carolinensis*, but especially in the inflorescence which is irregularly racemose, whereas that of *V. Carolinensis* is more cymose and much longer pedicelled.

Vincetoxicum crenatum

A twining vine. Stems somewhat angled, papillose-puberulent and retrorsely hirsute with scattered short hairs: leaves opposite, on slender, striate, 3–5 cm. long petioles; blades yellowish-green, 6–9 cm. long, ovate, rather long-acuminate at the apex, cordate, basal lobes rounded with open or closed sinus, papillose-puberulent on both surfaces, paler beneath: inflorescence sub-corymbose; peduncles 5–8 cm. long, 4–10-flowered; pedicels slender, 8–15 mm. long, 1–2 bracteolate at base: calyx-segments ovate, acutish, puberulent outside, ciliate, glabrous, and with a subulate gland in each sinus within: corolla 13–14 mm. long, dull yellowish purple, rotately spreading, ovate-conic in bud; segments linear-oblong, acutish, puberulent outside, glabrate within and vertically reticulated, sparingly and minutely hirsute below the sinus, transversely wrinkled and glabrous in the short tube: crown shallow, saucer-shaped, 5-crenate; lobes rounded, not exceeding the anthers, each with a short, barely free internal process or appendage at about the middle; process truncate at the apex: stigma 5-angled, not depressed: anther-appendages small, fleshy; pollinia obliquely semi-orbicular, saccate and broader at the summit, dented at the angled base, caudicles and corpuscles short. Follicles not seen.

Mexico: Barranca near Cuernavaca, State of Morelos, Pringle, no. 6388, July 27, 1895.

Distributed as *Gonolobus pilosus* Benth. Resembling in habit *Gonolobus angustilobus* Rob. & Greenm. (Proc. Am. Acad. **29**: 388. 1894) from the State of Jalisco, but differing in its yellowish-green foliage, the more numerous flowers and the curiously reticulated character of the corolla. The leaves of *G. angustilobus* are grayish-green, the flower appears to be solitary and the corolla is not at all reticulated. Detailed floral characters of this last species, owing to lack of material, are not accurately known.

In regard to the true *Gonolobus pilosus* Benth. (Pl. Hartw. 289. 1848) it is perhaps worth noting that a specimen collected by Dr. Coulter, in Mexico, no. 975, is preserved in the Herbarium of Columbia University. This number is quoted by Hemsley (Biol. Centr. Am. **2**: 333) as belonging to *Gonolobus pilosus* Benth. It coincides in every respect with the description of that species. The flowers are at least 3.5 cm. in diameter when open, and are of a dark, dull reddish-purple. The calyx-segments and bracteoles are over 13 mm. long, ovate, acutish and foliaceous. The crown is barely 5-parted, lacerate-denticulate along the whole margin, each division with an adnate, thickened internal appendage which is laciniate and barely free at the broadly quadrate summit. The pollinia are remarkably large, obliquely oblong, rounded at the base and somewhat saccate, slightly tapering to the curved caudicles; corpuscle broadly obovate at the apex, abruptly contracted to the much narrower rounded base. The hyaline anther-tips are conspicuously large.

Vincetoxicum Greggii

Gonolobus productus Torr. Mex. Bound. Surv. 165. 1859. In part.

A slender, twining vine. Stems minutely puberulent and hirsute with short scattered hairs: leaves opposite; petioles 5–15 mm. long; blades 1.5–3 cm. long, or more, ovate-hastate, long-acuminate at the apex, the basal lobes rounded with open sinus, rather thick, papillose-puberulent on both surfaces: inflorescence subcorymbose; peduncles 1.2 cm. long, 5–8-flowered: calyx 2 (?) mm. long, minutely hirsute; segments ovate-triangular, acute, with a subulate gland in each sinus: corolla subrotate, 6–7 mm. long;

crown 5-parted, to below the middle; segments thick and fleshy, broadly rounded at the apex, each with an internal ligulate horn or process arising from near the base, exceeding the anthers and incurved over them: stigma 5-angled: pollinia quadrate on slender, winged caudicles, corpuscle narrowly oblong. Follicles not seen.

"Slender vine-like plant, flower purplish," Cadena, Mexico, Dr. Gregg, May 8, 1847.

The specimen described here is in the Herbarium of Columbia University and was included by Dr. Torrey in his description of *Gonolobus productus* and was ticketed under that name by Dr. Gray when he revised the Torrey Collection for the Synoptical Flora. It is closely allied to **Vincetoxicum acuminatum** (*Gonolobus acuminatus* A. Gray, Proc. Am. Acad. **21**: 399. 1888–6) as well as to **V. productum** (*Gonolobus productus* Torr.) All three species belong in Dr. Gray's section *Chthamalia* and without careful dissection could scarcely be distinguished one from the other, except that *V. Greggii* has a more rotately spreading corolla than its congeners.

There are marked differences in the pollinia of the three species. In *V. productum* the pollinia are spreading and perhaps subpendulous, obliquely oblong, twisted (?) and somewhat bent or dented at the middle; the caudicles are apparently winged and the corpuscle is oblong, also appearing as if winged. The pollinia of *V. acuminatum* are more truly horizontal, subovoid, rounded on one side and straight on the other, on broad caudicles, with a broad corpuscle. *V. Greggii* has ovoid-quadrate pollinia, with very slender, somewhat twisted caudicles and a slender oblong corpuscle. In this last species the leaves are smaller than in the two others, the corolla is more rotately spreading, the crown is more deeply parted and the internal ligules are free and incurved over the anthers. The pollinia and crown characters of *V. Greggii* are also nearly those of *Gonolobus bifidus* Hemsley, but in that species the corolla is much smaller and truly rotate. In *V. acuminatum* the crown-segments are quadrate at the apex and the internal processes are short, barely free at the apex.

[Reprinted from the Bulletin of the Torrey Botanical Club, 28: August, 1901.]

Studies in the Asclepiadaceae.—V. A New Species of Vincetoxicum from Chihuahua

By Anna Murray Vail

(With Plate 30)

Vincetoxicum Wootonii

(*Gonolobus* A. Gray, non Michaux)

A low branching perennial herb with small axillary subumbellate clusters of dull greenish-purple flowers : stems angled, puberulent with short, apparently twisted hairs : leaves opposite, on petioles 3–5 mm. long ; blades 7 mm.–1 cm. long, pale grayish-green, round-ovate, obtuse at the apex, cordate, the basal lobes rounded, obtuse, thick and coriaceous, glabrous above, puberulent on the veins beneath, ciliate : peduncles 5–12 or 15 mm. long, 3–6- or 7-flowered, puberulent : pedicels very slender, 4–6 mm. long, puberulent, bracteolate at base : calyx-segments ovate-lanceolate, less than 2 mm. long, acute, puberulent, purplish, eglandulose at the base within : corolla-segments rotately spreading, dull yellowish-green, thickish, less than 4 mm. long, oblong-ovate, obtuse, glabrous, vertically reticulated, subglobose? in bud : corona saucer-shaped, 5-lobed, somewhat higher than the anthers, fleshy ; lobes broadly rounded, thickened at the center on the inner side, appendaged with 5 ligulate *Asclepias*-like incurved horns which adhere to the lobe to near the middle : stigma flat, barely 5-angled : pollinia obliquely semi-orbicular ; caudicles broadly winged, very slender at the attachment to the narrowly oblong corpuscle.

Nearly related to *Vincetoxicum biflorum* (Raf.) Heller and remarkable for the small leaves and *Asclepias*-like horns.

Mexico: State of Chihuahua, Colonia Garcia, Sierra Madre, altitude about 7200 ft., collected by Elmer O. Wooton, no. 13, June, 1899.

Explanation of Plate 30

Fig. 1. *Vincetoxicum Wootonii*, slightly reduced.
Fig. 2. Flower diagrammatically enlarged, × 5.
Fig. 3. Flower enlarged, × 2½.
Fig. 4. Corona diagrammatically enlarged.
Fig. 5. Pollinia enlarged, × 50.

[Reprinted from the Bulletin of the Torrey Botanical Club, 29 December, 1902]

Studies in the Asclepiadaceae—VI. Notes on the Genus Rouliniella

By Anna Murray Vail

A close examination of herbarium specimens variously labelled *Roulinia Jacquinii*, *R. unifaria* and *R. racemosa* show that there are several species which if not new are at least deserving of recognition; and this is an attempt to straighten out some of the species of a most interesting little genus.

About twenty-one or twenty-two species can be enumerated, ranging from Texas to Argentina; but as the genus is but poorly represented, even in foreign herbaria, it is difficult without careful dissection to determine whether all the species credited to *Roulinia* are correctly placed.

Rouliniella

Roulinia Decne.; D. C. Prod. 8: 516. 1844; Schumann, Die nat. Pflanzenfam. 4²: 255. 1895. Not Brongniart, 1840.

The seven species enumerated here all bear small flowers and are closely related. The available material of the South American species is at present too scanty to study with any kind of satisfaction.*

Key to the Species

- Crown-segments not exceeding the stigma. 1. *R. unifaria.*
- Crown-segments barely exceeding the stigma, conspicuously 3-lobed. 2. *R. Columbiana.*
- Crown-segments exceeding the stigma, long-ligulate.
  - Flower-buds sub-globose.
    - Central lobe of the crown-segments obscurely 3-toothed at the apex; flower-buds obtuse. 3. *R. Palmeri.*
    - Central lobe of the crown-segments entire; flower-buds acutish. 4. *R. racemosa.*
  - Flower-buds ovate, acute or sub-acuminate.
    - Central lobe of the crown-segments truncate at the apex. 5. *R. lignosa.*
    - Central lobe of the crown-segments acute at the apex. 6. *R. foetida.*
    - Central lobe of the crown-segments very long and slender, undulate. 7. *R. Jaliscana.*

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* The accompanying figures represent: *b*, the bud; *c*, the crown (diagrammatically enlarged); *f*, the expanded flower, and are all magnified four diameters; *p*, the pollinia, are magnified twenty diameters.

1. **Rouliniella unifaria** (Scheele)

Gonolobus unifarius Scheele, Linnaea, **21**: 760. 1848.
Roulinia unifaria Engelm. Mex. Bound. Surv. 160. 1850.

A slender climbing and twining vine. Stems pale gray-green when fresh, striate, glabrous or minutely pubescent in lines on the upper portion and somewhat sulcate: leaves opposite, on petioles 1–4 cm. long; blades 3–7 cm. long, ovate, somewhat hastately cordate, gradually acuminate, glabrous, thin, the auriculate basal lobes rounded, with a broad open sinus and a few glands at the base of the midvein above: peduncles longer than the petioles and as long as or exceeding the leaves: racemes as long or longer than the leaves, 7–12-flowered: rhachis minutely pubescent or puberulent in lines: flowers globose in bud: pedicels stout, 1 cm. long or less, pubescent: calyx-segments lanceolate-oblong, 4 mm. long, with a gland in each sinus: corolla 4–6 mm. long, white; segments 3 mm. long, linear-oblong, 2.5 mm. wide, broadly obtuse or nearly truncate, thin, 3-veined, the callous thickened margins revolute; crown attached to the base of the column, 5-parted to near the base; segments erect, not exceeding the anthers, minutely 3-lobed, the middle one slightly the longest, the lateral lobes with thin infolded margins at the base within: anther-wings small; anther-tips semi-orbicular, inflexed on the scarcely conic stigma: pollinia elliptical-ovoid; caudicles broad at the attachment, orange-red on the upper margin; corpuscle obtuse at the apex: follicles 6 cm. long, ovate, acuminate with an obtuse apex, coriaceous, glabrous: seeds 5 mm. long: coma 1 cm. long. (*Fig. 1.*)

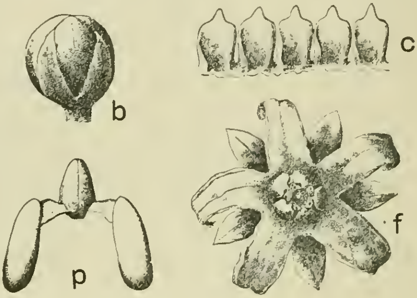

FIG. 1.

Type locality: On the Upper Guadeloupe River, near New Braunfels, Texas. Thickets, Kerr county, Texas, to "Mts. of Muerte," New Mexico. *Wright;* western Texas to El Paso, *Wright, 546;* near Kerrville, *Heller, 1899* (distributed as *Ampelanus ligulata*); Mexican Boundary Survey, *no. 1059*.

The specimens cited by Hemsley, for *Roulinia unifaria* from "North of Monclova, Coahuila," *Palmer, 829* are *Rouliniella Pal-*

meri. I have not seen any true *R. unifaria* as yet from Mexico. It closely resembles *R. racemosa* in general appearance, but in the latter species the leaves are commonly larger, the segments of the crown are 3-lobed, the central lobe long and acutely ligulate and the pollinia are oblanceolate in outline on very long slender caudicles. The crown-segments of *R. unifaria* are not long-ligulate and the pollinia are merely oblong in outline, the caudicles being very short and broad.

2. **Rouliniella Columbiana** sp. nov.

A twining vine up to 7 m. long. Stems puberulent or glabrate, slender: petioles channelled, 2–4 cm. long or somewhat shorter than the blades: leaves opposite; blades 3.5–8 cm. long, ovate-oblong, abruptly acuminate at the apex, the cordate basal lobes rounded, spreading, yellowish-green on both surfaces, sparingly pubescent with scattered hairs: racemes about the length of the petioles, 10–20-flowered: peduncles and pedicels puberulent, channelled: calyx-segments 2.5 mm. long, lanceolate, minutely puberulent: flowers sub-globose in bud, about 5 mm. in diameter when mature: corolla-segments 2 mm. long, apparently pale yellow, oblong, obtuse or acutish when dry, the margins revolute; crown 5-parted; segments white, 3-lobed, hood-like, the central lobe longer and incurved over the stigma, the lateral lobes with a narrow callous incurving ridge or crest on the inner side: anther-tips scarious, inflexed, conspicuous: pollinia oblong on broad caudicles. Follicles not seen. (*Fig. 2.*)

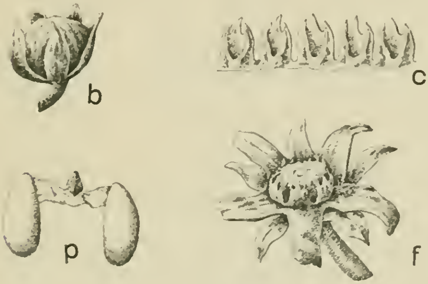

Fig. 2.

U. S. Colombia: Bonda, thickets on the lowlands near the river, 1898–99, rare: *Herbert H. Smith, 1668.* Flowers Oct.–Nov. Type in the herb. of the New York Botanical Garden.

3. **Rouliniella Palmeri** (S. Wats.)

Roulinia Palmeri S. Wats. Proc. Am. Acad. **18**: 115. 1883.

A slender twining nearly glabrous vine. Stems with a narrow puberulent line: leaves on slender 3–4 cm. long petioles; blades cordate-hastate, with a wide open basal sinus, acuminate at the apex, 3–8 cm. long, grayish-green, thin : inflorescence sub-corymbose : peduncles 3–5 cm. long, 5–7-flowered : flowers sub-globose in bud : calyx-segments slender, linear-lanceolate, 4–5 mm. long, puberulent : corolla greenish-white, obtuse in the bud ; segments somewhat crisped and revolute on the margin, a little longer than the calyx : crown-segments united at the base, quadrate, 3-lobed at the apex ; middle lobe triangular, acutish or obtuse, obscurely 3-toothed at the apex, a little longer than the infolded lateral lobes : stigma nearly flat : pollinia oblong ; caudicles broad, with an orange-colored spot along the upper margin : follicles 10 cm. long, somewhat spongy when dry, wrinkled, glabrous : seeds 7 mm. long, glabrous, crenate along the apex : coma 2.5–3 cm. long. (*Fig. 3.*)

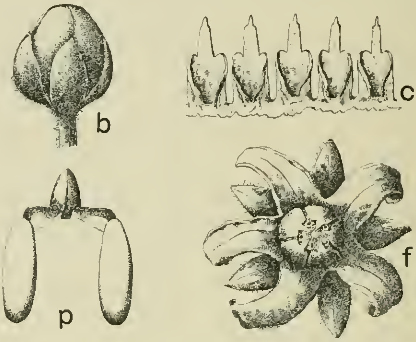

FIG. 3.

MEXICO : Mountains 24 miles northeast of Monclova, State of Coahuila, September 1880 ; *Palmer, 829.*

4. **Rouliniella racemosa** (Jacq.)

Cynanchum racemosum Jacq. Select. Am. 81. *pl. 54.* 1788.
Roulinia racemosa Kuntze, Rev. Gen. Pl. 422. 1891.

A much branched twining vine. Stems angled, slender, glarous except for a narrow pubescent line : leaves on petioles 2–4 cm. long ; blades ovate-cordate, 6–9 cm. long, long-acuminate, with broadly rounded basal lobes and open sinus : inflorescence racemose, shorter than the leaves : peduncles 4–7 cm. long, 10–20-flowered : flowers 5 mm. in diameter, sub-globose in bud : calyx-segments lanceolate, acuminate, with a gland in each sinus : corolla greenish-white ; margins of the lobes crisped : crown-segments united at base, obtusely 3-lobed at the summit ; central lobe ligulate, twice or more longer than the

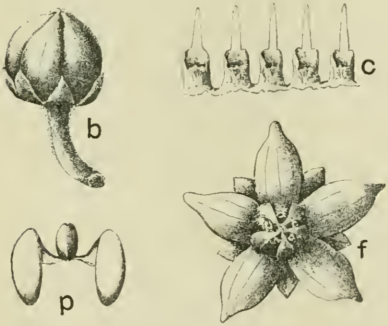

FIG. 4.

infolded lateral lobes: stigma rounded at the apex, scarcely conic: pollinia oblong; caudicles broad and short, with a deep orange-yellow spot along the upper margin; corpuscle large, bright red. Fruit not seen. (*Fig. 4.*)

Type locality, Cartagena, U. S. Colombia.

Guatemala: Patulúl, Depart. Sololá, alt. 3000 pp., *Heyde et Lux, 6349*, January, 1894.

Venezuela: near Tovar, *Fendler, 1055* (in herb. Gray).

5. **Rouliniella lignosa** sp. nov.

A woody vine. Stems pale grayish-brown, glabrous: branches 2–3 dm. long or more, somewhat angled, minutely tomentulose in lines, becoming glabrate: leaves opposite, on petioles 1.5–4 cm. long; blades ovate or sub-lanceolate, cordately hastate, 3–6 cm. long, gradually acuminate, rather thick, yellowish-green, glabrous above, minutely pubescent on the veins beneath; basal lobes rounded, short, with an open sinus, glandulose at the base of the midvein: peduncles longer than the petioles, pubescent: racemes slender, 5–7 cm. long, exceeding the leaves, 9–15-flowered: buds ovate: bracteoles very small, setaceous: pedicels 7–9 mm. long, slender, pubescent: calyx-segments ovate-lanceolate, 1 mm. long, puberulent with a minute gland in each sinus: corolla 5-parted to near the base, dull yellowish-purple, acute in the bud; segments 6 mm. long, acute, minutely hispidulous on the inner surface, with a callous ridge within the membranous whitish revolute margins: crown attached to the base of the column, 5-parted to the base; segments very thin, with somewhat involute lateral margins, prolonged into a long-ligulate obtuse or truncate apex, which is nearly as long as the corolla-segments: anther-wings very narrow and slender, not salient at the base: anther-tips ovate, inflexed over the barely conic, obscurely 5-rayed stigma: pollinia broadly oblong-ovoid; caudicles broad; corpuscle obtuse at the apex. Follicles not seen. (*Fig. 5.*)

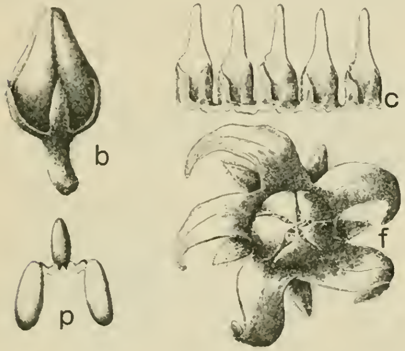

Fig. 5.

Mexico: State of Jalisco, Rio Blanco, 1886, *Palmer, 314*; (herb. Columbia University): "*Cynanchum parviflorum*" Pavon, in herb. Kew: Oaxaca, *Ghiesbreght* (also in herb. Kew). The last two specimens are cited in Hemsley, Biol. Centr. Am. **2**: 329 under *Roulinia Jacquini.*

Differing from *R. unifaria* and *R. racemosa* in its more woody stem and lighter green thicker leaves. It has the crown-segments of *R. racemosa* but the pollinia of *R. unifaria.*

6. **Rouliniella foetida** (Cav.)

Asclepias foetida Cav. Ic. **2**: 45. *pl. 158.* 1793.
Cynanchum foetidum H.B.K. Nov. Gen. Sp. **3**: 202. 1818?
Roulinia Jacquinii DC. Prodr. **8**: 517. 1844. *Excl. syn.*

A slender twining vine. Stems glabrous or with a narrow puberulent line: petioles slender, 3–7 cm. long: leaves opposite; blades ovate or some of the smaller ones ovate-lanceolate, 5–11 cm. long, acuminate at the slender apex, cordate at the base with open sinus and rounded basal lobes, puberulent on the veins beneath: flowers 8–12 mm. in diameter in small sub-umbellate clusters; buds ovate: peduncles minutely puberulent, 2–3 cm. long, commonly shorter than the petioles: calyx 1.5 mm. long; segments linear-oblong, acutish at the apex, minutely ciliate, with a large gland in each sinus: corolla 6–7 mm. long, dull-greenish, fleshy, glabrous on the outer surface, whitish or cream color? with two raised puberulent callous ridges or crests along the upper portion within; crown-segments white, very thin, 5, the lateral margins infolded and adnate to the inner surface, the long ligulate apex very slender, as long as the corolla segments or nearly so: anther-wings long and narrow: pollinia oblong, on short broad pale yellow caudicles; corpuscle reddish, rounded at the apex, narrower at the bifid base: stigma barely conic, 5-rayed: follicles angled and winged. Mature follicles not seen. (*Fig. 6.*)

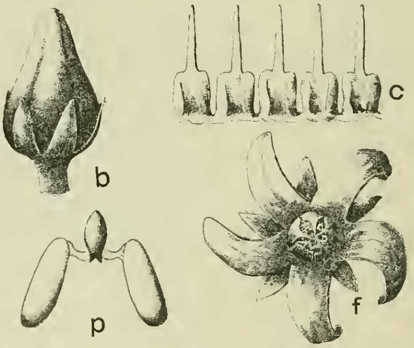

FIG. 6.

MEXICO: Oaxaca, *Galeotti, 1538* (in herb. Kew); near Oaxaca, alt. 1600 m., 1896, *C. Conzatti, 217;* Valley de Etla, Sept. 1895, *C. Alvarez, 768;* Huitzo, alt. 1700 m., 13 Aug. 1897, *C. Conzatti & V. Gonzales, 336* (in herb. Gray).

The plant from which the Cavanilles figure was drawn is said to have been grown at the Royal Botanic Garden, Madrid; and was native of Mexico. It agrees well with the specimens just cited, though in detail the central lobe of the crown-segments seem shorter.

7. **Rouliniella Jaliscana** sp. nov.

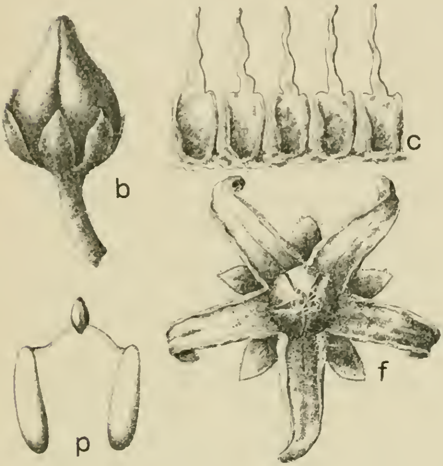

FIG. 7.

A twining vine. Stems glabrous, angled: branches glabrous or with a narrow puberulent line above: petioles channeled? 2–7 cm. long or more, glabrous or minutely puberulent: leaves opposite; blades 4–12 cm. long, ovate-oblong, abruptly acuminate at the apex, truncate at the base, dark green or glabrous above, paler, glabrous or minutely puberulent on the veins beneath: racemes shorter than the leaves, 8–12-flowered: buds ovate: peduncles minutely puberulent in lines, channeled: calyx-segments oblong, obtuse, 2 mm. long, minutely ciliate, oblong-linear: corolla-segments 4–5 mm. long, broadly obtuse or truncate at the obtuse somewhat ligulate revolute apex, with a narrow callus incurving ridge or crest on each side near the middle within: crown-segments white, 3-lobed, the lateral lobes infolded within; the central lobe long-ligulate, very slender, undulate, nearly as long as the corolla-segments: anther-wings very short, corneous: stigma 5-rayed, flattish: anther tips semi-orbicular, inflexed: pollinia oblong, pyriform on long slender caudicles: corpuscle lozenge-shaped. Follicles not seen. (*Fig. 7.*)

MEXICO: State of Jalisco, *Palmer*, *384;* State of Jalisco, *Pringle*, *4494;* Orizaba, *Botteri*. (Type in herb. of the New York Botanical Garden.)

NEW YORK BOTANICAL GARDEN.

Studies in the Asclepiadaceae—VII. A new Species of Vincetoxicum from Alabama *

By Anna Murray Vail

(With Plates 9 and 10)

Vincetoxicum Alabamense

High climbing, sparingly hirsute with long rather weak hairs and a minute glandular pubescence: petioles 3–8 cm. long, channelled; leaf-blades 6–15 cm. long, 5–10 cm. broad, rather thin, ovate or oblong-cordate, acuminate at the apex, the basal auricles rounded and never overlapping, the sinus narrow at the base, sparingly puberulent and dark green above, lighter and more closely puberulent beneath: peduncles shorter than the petioles, 3–6-flowered: calyx bi-glandulose, the lobes lanceolate, acute: corolla dull greenish-yellow, 2 cm. in diameter, 5-parted to near the base; segments oval, obtuse, puberulent and minutely papillose on the outer surface, conspicuously reticulated within; gynostegium raised on a low broad column; crown orange-yellow, consisting of a low saucer-shaped ring attached to the base of the corolla, 5-parted, each division minutely and irregularly toothed or entire, appendaged within by 5 tooth-like erect crests attached to the base of the column; stigma white, flat, obtusely 5-angled: anther-tips white, scarious; pollinia obovate: ovaries minutely puberulent: follicles 8–9 cm. long, glandular-puberulent, closely and strongly muricate: seeds 8–9 mm. long, obovate, granulose, tipped by a tuft of long silky coma.

"Sandy hillsides on edge of woods," Dale County, Alabama, collected by T. G. Harbison, June 3 and September 5, 1902.

Differing from *Vincetoxicum reticulatum* (Engelm.) Heller in the greater size of its leaves and flowers, the more strongly muricate follicles and the horn-like appendages to the crown.

In *Vincetoxicum reticulatum* the leaf-blades are 3–6 cm. long, the basal sinus broad with often overlapping auricles; the racemes are mostly the length of the petioles; the flowers are scarcely more than 1.4 cm. in diameter when expanded; the crown is very obscure, and the horn-like projections of the column are also obscure or lacking.

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* Presented by invitation before the Botanical Society of America, Washington, D. C., January 1, 1903.

NEW YORK BOTANICAL GARDEN.

Explanation of Plates

PLATE 9. *Vincetoxicum Alabamense*

a. Flower enlarged, × 3.

b. Calyx (without the corolla) enlarged, × 8.

c. Sepals (showing the two glands) enlarged, × 16.

d. Ovaries enlarged, × 16.

e. Pollinia enlarged, × 20.

f. Diagrammatic transverse section of gynostegium enlarged, × 16.

g, *h.* Different aspects of the outer and inner crown (the gynostegium cut off) enlarged, × 16.

PLATE 10. *Vincetoxicum reticulatum*

a. Flower enlarged, × 3.

b. Calyx (without the corolla) enlarged, × 8.

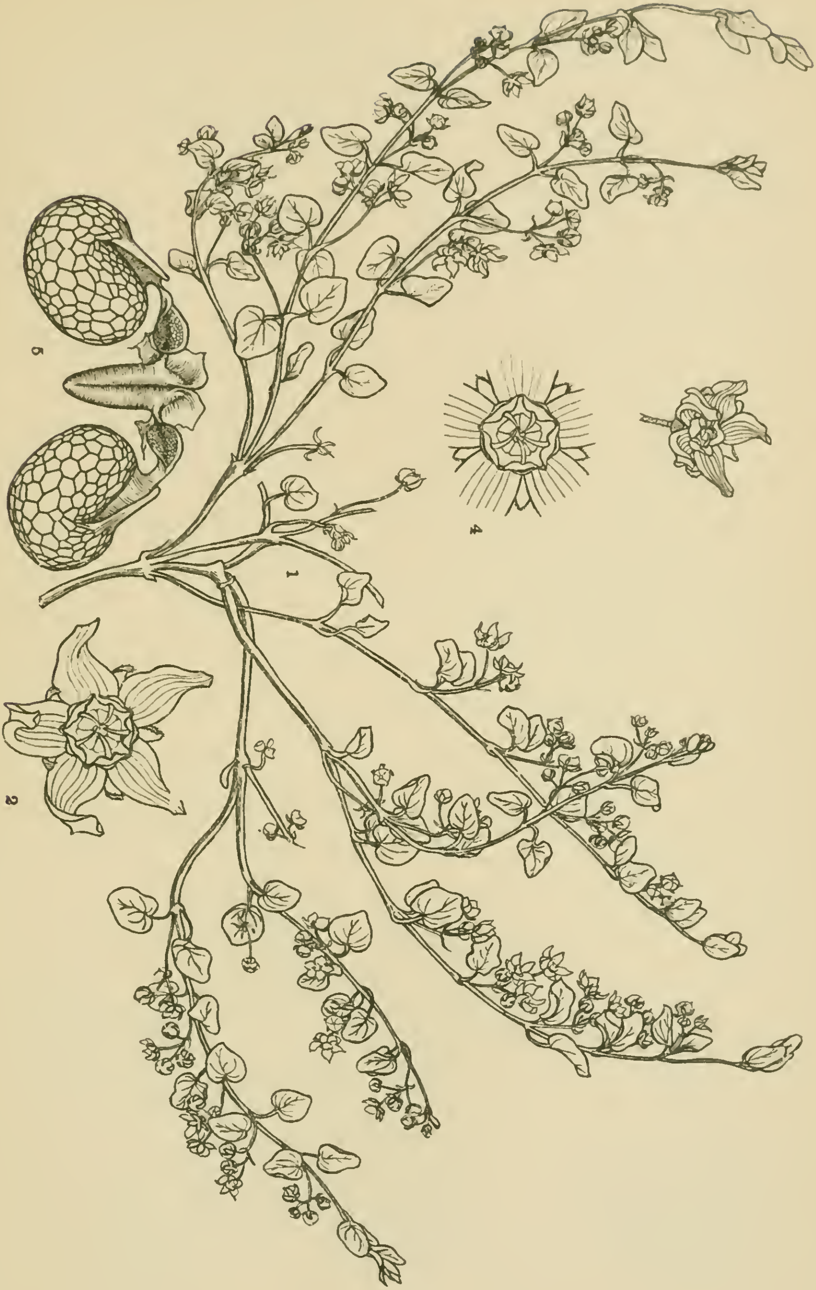
c. Sepal (showing the solitary gland) enlarged, × 16.

d. Ovaries enlarged, × 16.

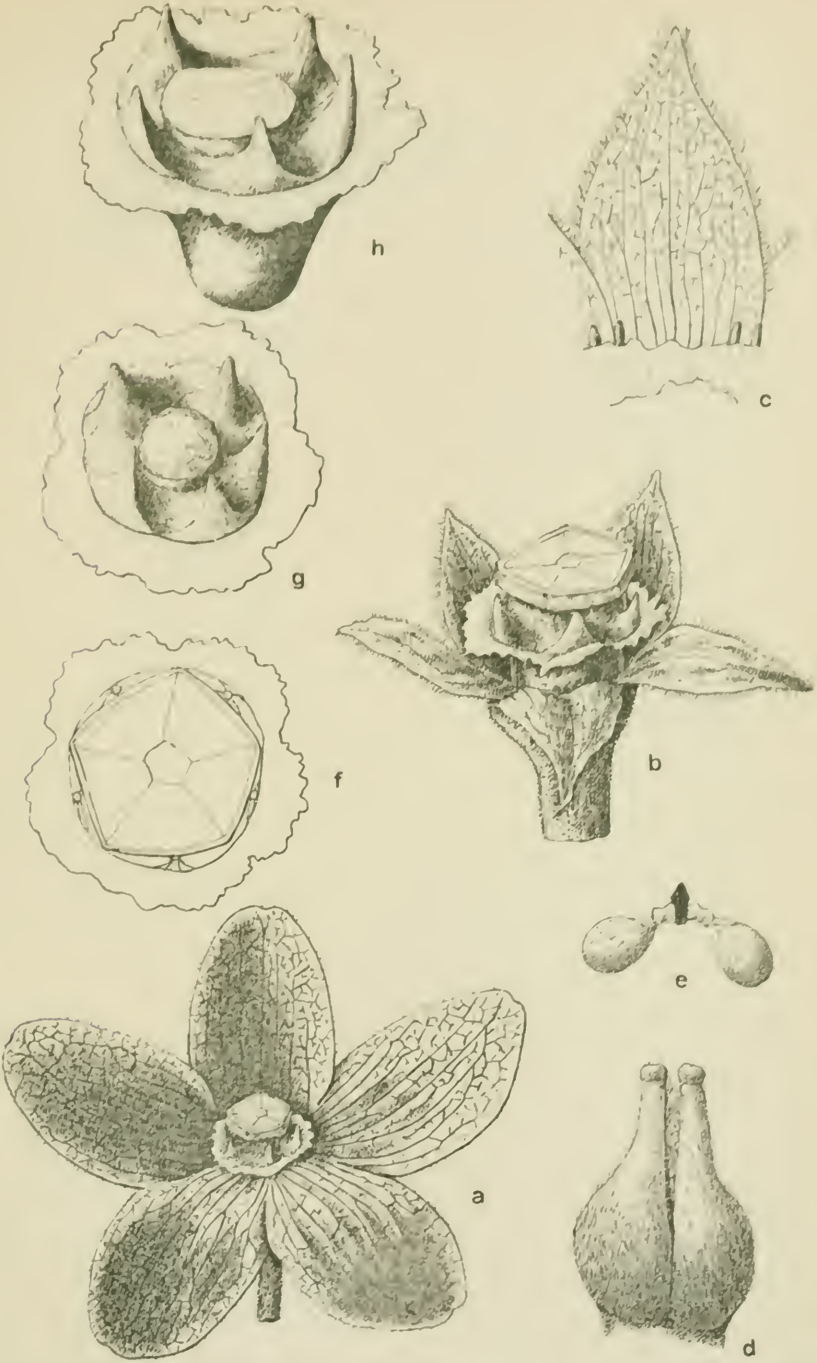
e. Pollinia enlarged, × 20.

f. Diagrammatic transverse section of gynostegium enlarged, × 16.

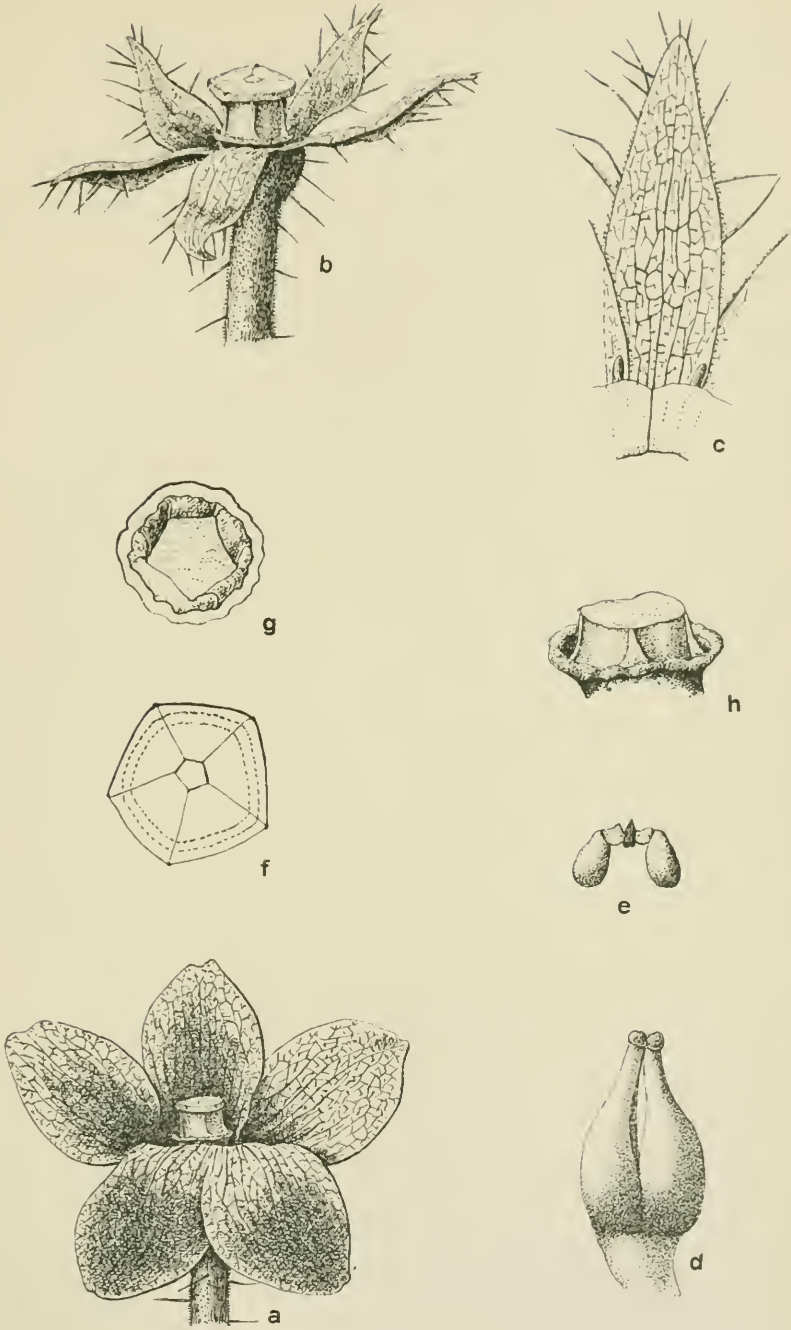
g, *h.* Different aspects of outer and inner crown (the gynostegium cut off) enlarged, × 16.



VINCETOSCICUM WOOTONII



VINCETOXICUM ALABAMENSE Vail.



VINCETOXICUM RETICULATUM (Engelm.) Heller.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 34.

THE GENUS RIELLA, WITH DESCRIPTIONS OF NEW SPECIES FROM NORTH AMERICA AND THE CANARY ISLANDS

By M. A. HOWE and L. M. UNDERWOOD

NEW YORK

1903

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The Genus Riella, with Descriptions of new Species from North America and the Canary Islands*

By M. A. Howe and L. M. Underwood

(With Plates 11 and 12)

The genus *Riella* occupies a unique position among the Hepaticae. The striking peculiarities of its gametophytic phase have attracted the attention of such morphologists as Hofmeister, Leitgeb, and Goebel, in addition to the interest excited among those who have devoted themselves more exclusively to a study of the systematic relations of the Hepaticae. *Riella helicophylla*, an Algerian species, is alluded to in some of the standard botanical text-books as being peculiar among the liverworts in having a leaf-like lamina or wing disposed spirally in relation to the axis or stem. Later studies of this species, however,† indicate that the supposed helicoid spiral arrangement was exaggerated in the original figures and description and that the spiral appearance is due to the slight torsion of a stem bearing a strongly undulate lamina. Nevertheless, the species of *Riella* in general are peculiar enough in that the lamina or wing appears at first sight to be attached to one side of the stem; but the position of the sexual organs, of the root-hairs and of the scale-like appendages shows that the plant is bilaterally symmetrical in the plane of the wing and the conviction is now general that the wing is dorsal in relation to the stem. Goebel‡ has expressed the opinion that the chief difference between *Riella* and the other liverworts is that in *Riella* the development of the thallus is in the vertical instead of in the horizontal plane. The species of *Riella* are all aquatic, commonly growing entirely submerged, and it is doubtless this condition of growth which makes possible the leading peculiarity in form.

The growing point of a young plant or of a young branch of

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* Read in abstract before the Botanical Society of America, Ninth Annual Meeting, Washington, D. C., December 31, 1902.

† Trabut, Rev. Gén. Bot. 3: 451. 1891. Stephani, Bull. Herb. Boiss. 7: 659. 1899.

‡ Flora, 77: 107. 1893.

Riella is not apical in the ordinary sense of the word, but intercalary. The whole tissue of the young shoot appears to be meristematic at first and of one layer of cells. Later, the growth activities are concentrated at either one or two points on the margin of the shoot intermediate between its distal and proximal extremities. If at *two* points, these are situated on opposite margins of the shoot. The new cells formed on the upper or distal side of the growing point now contribute to the growth of the unistratose wing, which is dorsal in position. The new cells formed on the lower or proximal side of the growing point go to constitute the multistratose stem, which is ventral in position. If two growing points on opposite margins of a young shoot persist, a double or twin plant is formed, the two branches of the axis bearing a single continuous dorsal wing. If, however, only one growing point persists, the plant or branch is apparently one-sided, with stem on one side and wing on the other, though in reality the wing is dorsal and the stem ventral.

On account of the absence of elaters, *Riella* was at first placed with the Ricciaceae, together with *Sphaerocarpus*, in which, likewise, elaters are not developed. A better understanding of the morphology of these two genera has led to placing them in the order Jungermanniales, of which, together with the exclusively American genus *Thallocarpus*, they constitute the simplest members. The genus *Riella* forms the subfamily Rielloideae and in the usual arrangement stands between the Sphaerocarpoideae and Metzgerioideae in the family Metzgeriaceae (the Jungermanniaceae anakrogynae of Leitgeb and Schiffner).

The geographical distribution of this strongly characterized genus *Riella* is of interest. Up to within a few months ago, the genus was supposed, as far as the literature on the subject is concerned, to be confined to the Mediterranean drainage basin of Africa and Europe, with seven species, as commonly recognized. One of these, however, *Riella Gallica*, was reduced by M. Corbière in the last number of the Revue Bryologique for 1902 to forma *Gallica* of the Algerian *R. Battandieri*. To these seven known species, or six, as now conceived, another from a region far removed was added by Morten P. Porsild in a recent number of the Botanisk Tidsskrift, where *R. Paulsenii* from Turkestan was described and figured. References to the principal literature dealing with the genus, together with the names and distribution of the species hitherto described, are given below:

Riella Mont. Ann. Sci. Nat. III. **18**: 11. 1852. Leitgeb, Untersuch. Leberm. **4**: 74–87. *pl. 7, 8. f. 1–8.* 1879. Trabut, Rev. Gén. Bot. **3**: 449. 1891. Goebel, Flora, **77**: 104–108. *pl. 2. f. 1–3.* 1893. Schiffn.; E. & P. Nat. Pflanzenfam. **1**^{3}: 51. 1893. Stephani, Bull. Herb. Boiss. **7**: 658. 1899.

Duriaea Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1115. 1843; Ann. Sci. Nat. III. **1**: 228. 1844. G. L. & N. Syn. Hep. 593. 1846. Not *Durieua* Mérat, Mém. Soc. Roy. Sci. Lille, **1827–28**: 432. 1829. Not *Durieua* Boiss. & Reut. Diag. Pl. Nov. Hisp. 14. 1842.

Maisonneuvea Trevis.* Mem. R. Ist. Lomb. III. **4**: 442. 1877.

Duriella Clauson & Billot, *fide* Schiffn., *l. c.*

Riella Battandieri Trab. Rev. Bryol. **13**: 55. *pl. 3.* 1886. Schiffn. Bot. Centralb. **27**: 240. *pl. 1. f. 5.* 1886.

Algeria: Maison-Blanche near Algiers, *Battandier, Trabut.*

Exsicc.: Husnot, Hep. Gall. no. 173.

Forma Gallica (Bal.) Corbière, Rev. Bryol. **29**: 113. 1902.

Riella Gallica Bal.; Trab. Rev. Gén. Bot. **3**: 450. *pl. 18. f. G.* 1891.

France: Roquehaute, near Béziers, Hérault, *Balansa*, 1866, *Crozals*, 1902; mare de Rigaud near Agde, Hérault, *Crozals*, 1902.

Riella Cossoniana Trab.; Batt. & Trab. Atlas Fl. Alg. **1**: 6. *pl. 2. f. 1–8.* 1886; Rev. Bryol. **14**: 12. *pl.* 1887.

Algeria†: El Kreider, Province Oran, *Cosson*, 1854; *Trabut*, 1885.

Exsicc.: Husnot, Hep. Gall. no. 174.

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* Trevisan rejected *Riella* Mont. on account of *Riella* Raf.; Lév.; Orb. Dict. Univ. Hist. Nat. **8**: 488. 1849. This, however, is a *nomen nudum* and is probably a misprint for *Rimella* Raf. Jour. Phys. **89**: 106. 1819.

† Allusions to the occurrence of *Riella Cossoniana* in the Canaries have recently appeared in print (Bot. Tidsskrift, **24**: 327. 1902; Rev. Bryol. **29**: 110. 1902), but it is possible that these refer to *Riella affinis*, described below as new.

RIELLA HELICOPHYLLA (Bory & Mont.) Mont. Ann. Sci. Nat. III. **18**: 12. 1852; Syll. Gen. Sp. Crypt. 94. 1856.

Duriaea helicophylla Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1116. 1843; Ann. Sci. Nat. III. **1**: 229. 1844. G. L. & N. Syn. Hep. 593. 1846. Mont.; Bory & Durieu, Expl. Sci., Algérie, Bot. *pl. 34.* 1846–49.

ALGERIA: Province Oran, *Durieu*, *Trabut.*

EXSICC.: Husnot, Hep. Gall. no. 172.

RIELLA NOTARISII (Mont.) Mont. Ann. Sci. Nat. III. **18**: 12. 1852; Syll. Gen. Sp. Crypt. 94. 1856.

Sphaerocarpus Notarisii Mont.; De Not. Mem. R. Accad. Torino, II. **1**: 343. *f. d. 1–8.* 1839.

Duriaea Notarisii Bory & Mont. Compt. Rend. Hebd. Acad. Sci. **16**: 1116. 1843; Ann. Sci. Nat. III. **1**: 229. 1844. G. L. & N. Syn. Hep. 593. 1846.

SARDINIA: near Pula, *De Notaris*, 1834.

GREECE: Phalerus, *Chaboisseau*, *fide* Stephani.

RIELLA PARISII Gottsche; G. & R. Hep. Eur. no. 375. 1867. [Illust.] Leitgeb, Untersuch. Hep. **4**: 76. *pl. 7. f. 17.* 1879. Stephani, Bull. Herb. Boiss. **7**: 661. 1899.

Riella Clausoni[*s*] Letourneux; Husnot, Hepaticologia Gallica, 87. *pl. 12. f. 151.* 1881. Batt. & Trab. Atlas Fl. Alg. **1**: 13. *pl. 8.* 1886. Trab. Rev. Gén. Bot. **3**: 452. 1891.

ALGERIA: Maison-Carrée, etc., near Algiers, *Clauson*, *Paris*, *Trabut.*

EXSICC.: G. & R. Hep. Eur. no. 375; Husnot, Hep. Gall. no. 121.

RIELLA PAULSENII Porsild, Bot. Tidsskrift, **24**: 323–327. *f. 1–3.* 1902.

TURKESTAN: Bokhara, *Paulsen*, 1898.

RIELLA REUTERI Mont. Ann. Sci. Nat. III. **18**: 12. 1852. Hofmeister, Bericht. Verh. Kgl. Sächs. Gesellsch. Wiss. 1854: 92–95. *pl. 4.*

SWITZERLAND: near Geneva, *Reuter*, 1851.

In describing *Riella Paulsenii*, the first species of the genus known to occur outside of the Mediterranean region, Porsild expresses the surmise that the distribution of the genus may prove to be still more widely extended, which is well verified by the known existence at the present time of three specimens of *Riella* collected within the boundaries of the United States. One of these, strangely enough, was collected by Schott as long ago as 1855, but has remained unstudied and unnoted in literature. In April, 1902, western Texas, the region from which Schott's specimens came, was visited by Professors F. S. Earle and S. M. Tracy, who secured further specimens which we consider the type of the well-marked species described below :

Riella Americana sp. nov.

Erect or ascending, 10–30 mm. high, simple or more commonly 1–4 times furcate : axis elliptical in section, 0.2–0.8 mm. wide, mostly 6–10 cells thick, root-hairs borne only on the basal parts and usually few : wing 2–5 mm. broad, rounded-falciform at apex, slightly undulate-crisped, subentire or erose, tapering toward the base and commonly deficient below the first dichotomy ; cells near the axis about 60 μ in greatest diameter, those near the margin about 40 μ : scales few, small, 0.2–0.6 mm. long, linguiform and obtuse or irregularly lanceolate and subacute, those near the growing apex usually intermingled with multicellular gemmae : gemmae trichomic in origin, soon oblong or orbicular-oblong in outline, showing later a median constriction and becoming finally panduriform and subspatulate : dioicous : antheridia about 0.36 × 0.16 mm., sometimes as many as 75 (including empty loculi) in a single elongated marginal series : ♀ gametophyte, or each of its branches, maturing for the most part 3–12 sporogonia in acropetal order : involucres smooth, ellipsoidal-ovoid or at full maturity subglobose-ovoid, 1.4–1.8 mm. × 0.8–1.2 mm., narrowed rather gradually to the truncate or slightly pointed subpapillose orifice : capsule globose, 0.8–1 mm. in diameter, seta about 0.2 mm. long, mostly a trifle shorter than the ovoid-conic foot : spores dark-brown, 100–130 μ in maximum diameter (spines included) ; outer face bearing numerous sometimes curved spines 10–24 μ long, with dilated apices, these spines more or less connected by radiating basal membranes forming irregular reticulations ; inner faces bearing conical, non-capitate spines, 3–6 μ long, with basal membranes obsolescent or entirely wanting. (*Pl. 11 ; pl. 12, f. 21, 22*).

Limpia Cañon, Texas, F. S. Earle and S. M. Tracy, April 25, 1902, no. 251 ; this, the type specimen, is deposited in the herbarium of the New York Botanical Garden. The plants are said by Professor Earle to have been found in a pool headed by a small waterfall, forming mats on rocks and stones which were covered by 10–60 cm. of water in the dry season. The same species was collected by Schott in 1855, his specimen originating from "Limpia, near its head, Western Texas." His plants, though otherwise agreeing perfectly with those of the more recent collection, are considerably smaller and are mostly unbranched. A *Riella* (in herb. A. W. Evans) was collected by Mr. De Alton Saunders at Brookings, South Dakota, in 1898. The material is scanty and the sporogonia are so immature that the spore-characters cannot be determined. The involucres and scales are similar to those of *R. Americana* and it is quite probable that the species is the same. This South Dakota specimen marks the northern limit in the known distribution of the genus.

Riella Americana is easily distinguished from any of the species hitherto known. Its nearest ally is probably *Riella Battandieri* f. *Gallica*, of southern France, which differs in being monoicous,* in the narrower wing, the smaller spores, with shorter non-capitate spines, etc. Gemmae have not before, to our knowledge, been definitely described in any species of *Riella*, though Goebel (Flora, **77**: 105. 1893) in figuring three young stages of *Riella Battandieri* (?) remarks in a footnote that one of them sprang from a "Zellkörper" while the others came from "Zellfäden." By analogy with what we have observed in *Riella Americana*, it seems very probable that his plant from the "Zellkörper" came from a brood-body of some kind, while those from the "Zellfäden" were derived from spores. The young plants of *Riella Cossoniana*, represented by Trabut in his figures 1 and 2 (*l. c.*), also, with little doubt, originated from gemmae. The gemmiform appendages figured by Trabut on the axis of his *R. Gallica* are of a more doubtful nature. These were not found by Corbière in his recent studies of what he believes to be the same species; possibly they were designed to represent remains of old involucres and sporogonia.

The gemmae of *R. Americana* originate on the axis as trichomic outgrowths, each of about three cells in a single series (*f. 10, 11*) of which the terminal cell is usually the largest. The two lower cells then divide in the sagittal plane (*f. 11*) and this this is followed by a division of the terminal cell. The basal cells afterward grow out and divide in such a way as to give the body a free margin throughout its periphery, though it remains attached to the axis for a considerable time by a single cell on its proximal surface. *F. 13–16* show stages in the subsequent development, *14* being a view of its proximal surface, and *13*, *15* and *16* of its distal, the point of attachment in each case being at *b*. The part which is derived from the base of the original trichome consists soon of cells which are smaller, richer in protoplasm, and capable of more rapid division than those of the part which is derived from the apex of the original trichome. This part of basal origin is more regularly suborbicular in outline than the other. In neither part can an apical cell be pointed out with any certainty. In the earlier stages the whole body seems to be meristematic; later a constriction appears near its middle and the formation of new cells is then the most active in the zone of this constriction. The larger-celled part, derived from the apex or distal end of the initial trichome, becomes at about this time more than one cell thick in its middle and terminal regions and shows papilliform outgrowths, the beginnings of the root-hairs. The smaller-celled portion derived from the base or proximal end of the initial trichome remains only one cell thick except in the isthmus of constriction where it finally, in part at least, becomes two or more cells thick. *F. 16* shows a well-developed gemma inverted as regards its original relations to the axis of the gametophyte. The edges of the two parts here overlap slightly in the zone of constriction. Later, the isthmus elongates, giving the body a somewhat panduriform or at length subspatulate outline. *F. 17* shows the outline of a gemma in an older stage, and *f. 18* a still later development.

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* Corbière, Rev. Bryol. **29**: 111, 113. 1902.

Attempts to germinate the spores of the plants collected by Earle and Tracy were made in the autumn and winter of 1902–03. Though the spores were to all appearances mature, the attempts were successful in the case of only a very few spores, which were carried a little beyond the stage represented in our *f. 21* and *f. 22*. The germ-tubes in every case observed came out from near the middle of the outer or more spiny face. This tube is first divided by transverse walls into a single row of several cells, three or four of the terminal of which are then divided by median longitudinal walls. This divided terminal portion by growth and multiplication of its cells becomes ovate or spatulate in outline. In the latest stage that we have been able to see, one somewhat more advanced than that represented in our *f. 21*, the whole body still consists of only one layer of cells. *F. 22* shows in edgewise view the same plant that is shown in *f. 21*. A root-hair is sent out from the spore soon after the emergence of the germ-tubes.

A second species of *Riella*, apparently new, from the Canary Islands, has come to our attention; this we would describe as follows:

Riella affinis sp. nov.

Apparently erect or ascending, becoming prostrate on the subsidence of the water, 6–15 mm. high, densely caespitose, simple or sparingly furcate: axis flattened, 0.1–0.4 mm. wide, mostly thin and flaccid, radicelliferous at base: wing 1–3 mm. broad, rounded or obtusely pointed at apex and falciform, deeply lobed; cells near the axis 45–60 μ in diameter, those near the margin about 30 μ: scales usually inconspicuous, 0.2–0.5 mm. long, linguiform, lanceolate, or linear, obtuse or acute: monoicous: antheridia solitary or in groups of 2–7 in more or less profound marginal sinuses: sporogonia mostly 3–10: involucres ovoid, 8-winged, 1.4–2 mm. long, 1–1.5 mm. wide (incl. wings), much contracted and often subacute at mouth; wings 0.1–0.2 mm. broad, with undulate-sinuate or subentire margin: capsule subglobose, 0.8–1 mm. in diameter, seta 0.1–0.2 mm. long: spores brown, 85–120 μ in maximum diameter (spines included); outer face densely covered with spines 6–15 μ long, their apices mostly truncate, often slightly dilated, occasionally emarginate-bifid, rarely acute, the supporting basal membranes sometimes almost deficient but commonly forming a few imperfect areolae; inner faces with mostly truncate or obtuse spines or warts 3–6 μ high, basal membranes wanting. (*Pl. 12. f. 23–36.*)

On the bank of a reservoir, Tafira, Grand Canary, June, 1897, O. F. Cook (no. 729). We are informed by the collector that the specimens were found partly submerged and partly exposed on a sloping bank.

Riella affinis is allied to the Algerian *R. Cossoniana* Trabut and the central Asian *R. Paulsenii* Porsild, but differs from both in being monoicous and in the much longer spines of the larger spores. The involucres are less globose and more pointed at the apex than those of *R. Cossoniana.* Judging from two specimens of *R. Cossoniana* collected by Professor Trabut, *R. affinis* has the appearance of being a larger species with broader lamina, though this might not appear from a comparison of the measurements given above with those given by authors for *R. Cossoniana.* Our specimens of *R. affinis* are prostrate and more or less entangled with mud and are so delicate and fragile that it is quite possible that the measurements in the above description may fail to do full justice to the height of the plant. It may be remarked that in occasional capsules the spores though showing a well-developed brown coloration have short spines or papillae much like those of *R. Cossoniana ;* such spores are always smaller than is normal for the species and are probably immature or else have ripened under abnormal conditions.

Our experiments in germinating the spores of *Riella affinis* have been more successful than those with the spores of *Riella Americana*, though they were not begun until December, 1902, five and a half years from the date of collection of the specimens. More than half of the spores experimented with germinated in a few days by being placed on a piece of wet filter-paper in a glass dish kept in a moist chamber at ordinary living-room temperatures. The germ-tube in practically all cases emerges, as in *R. Americana*, from the outer or more spiny face of the spore, usually near its middle. The root-hair follows a little later, its lumen remaining continuous with that of the germ-tube. The length of the germ-tube varies exceedingly. Finally, there appears in it a somewhat curved transverse wall with its convexity turned toward the spore. The part above contains most of the starch grains and in the course of time begins to show chlorophyll, cell-divisions meanwhile taking place as described above for *R. Americana.* The length of the germ-tube from the spore-wall to the curved septum has been observed to vary in different cases from 0.02–0.7 mm. One or two root-hairs, in addition to the one which comes from the base of the germ-tube, may spring out later from some part of the filamentous stalk of the young gametophyte. The forms assumed by the young gametophytes are extremely varied and are doubtless determined to a considerable extent by the conditions of illumination, though no exact investigations were undertaken to demonstrate the influence of light in this matter. The prevailing form, however, while still unistratose, is spatulate, though flabelliform and linear outlines are not uncommon and grotesquely lobed and branched stages are often met with. Linear or ribbon-shaped forms, like that shown in *f. 36*, are especially common when the young plants are from the first well covered with water. Just below the chief growing point *c*, in the stage illustrated by *f. 34*, there are cell divisions in the plane of the paper, which possibly foreshadow the axis or stem, though they may have arisen in this case through changed relations to the light. We have not yet been able to follow the development much beyond this point, but we have grounds for believing that the subsequent history is essentially as described by Goebel (*l. c.*) for young plants of *A. Battandieri* with the exception that the wing is probably more lobed than in that species. In most cases, the development is confined to practically a single plane, though occasionally, as in the case represented by *f. 35*, the wing-lobes show an irregularly spiral arrangement, due perhaps to changed positions in regard to the light.

Explanation of Plates

[The drawings have been prepared by M. A. Howe, chiefly with the aid of a camera lucida.]

PLATE 11. *Riella Americana* Howe & Underw.

1 and 4. ♂ gametophytes, natural size.

2 and 3. ♀ gametophytes, natural size.

5. Terminal portion of a branch of the ♂ gametophyte, with a young branch at the apex, × 11.

6. Terminal portion of a branch of the ♀ gametophyte, × 11.

7. An involucre, with mature sporogonium, × 16.

8. A scale, × 55.

9. Portion of axis near the apex, showing gemmae and scales, × 40. The gemmae are shown at *a* and below; the scales are, in this case, nearer the wing.

10–18. Stages in the development of the gemmae. See text, pp. 219 and 220.

10. A trichome destined to become a gemma, in distal (outer) aspect, × 193.

11. A similar stage in lateral view, × 193.

12–15. Later stages; 12, 13, and 15 in distal aspect, 14 in proximal, × 193; *b*, point of attachment.

16. A more advanced stage, inverted as regards its original relations to the axis and as regards the preceding figures, × 193.

17. Outline of a gemma in a later stage, × 55.

18. A young gametophyte derived from a gemma, × 28.

19 and 20. Spores, outer and inner faces, × 305.

Figures 4, 18–20, are drawn from material collected by Schott in 1855; the others from material collected by Earle and Tracy, April, 1902.

PLATE 12

Figs. 21 and 22, *Riella Americana* Howe & Underw.; Figs. 23–36, *Riella affinis* Howe & Underw.

21. Germ plant, × 245.

22. Same in edgewise view, × 245.

23. Gametophyte of *Riella affinis*, × 11.

24. Apical portion of another, with involucres and antheridial loculi, × 11.

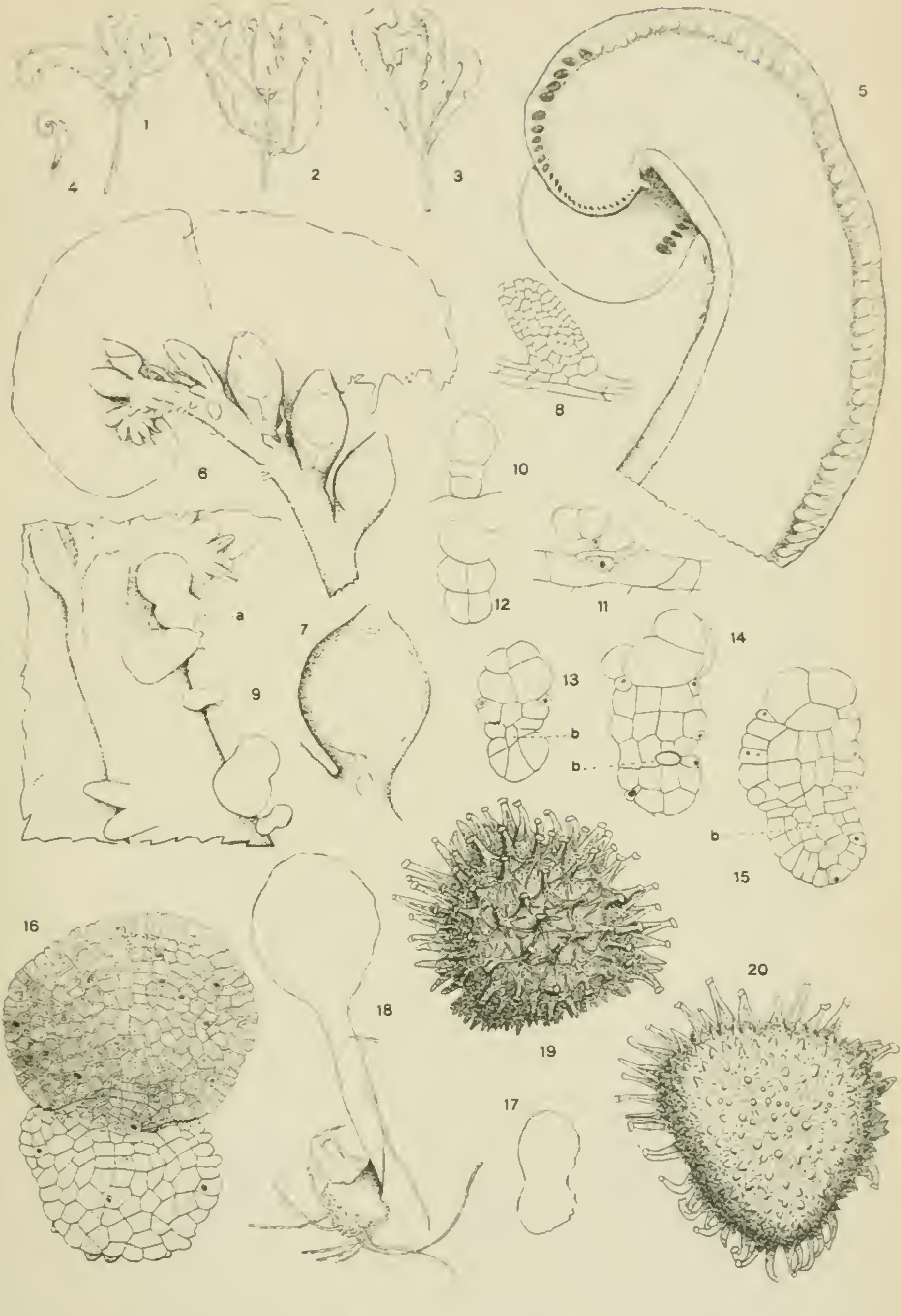
25 and 26. Involucres, × 16.

27 and 28. Spores, outer and inner faces, respectively, × 330.

29 and 30. Germinating spores, × 55.

31. Germ plant, showing the earlier cell divisions, × 245.

32–36. Various forms assumed by the germ plants, × 55. The principal vegetative point is indicated by *c*. The elongate form represented in Fig. 36 is common when the young plants are well covered with water.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6
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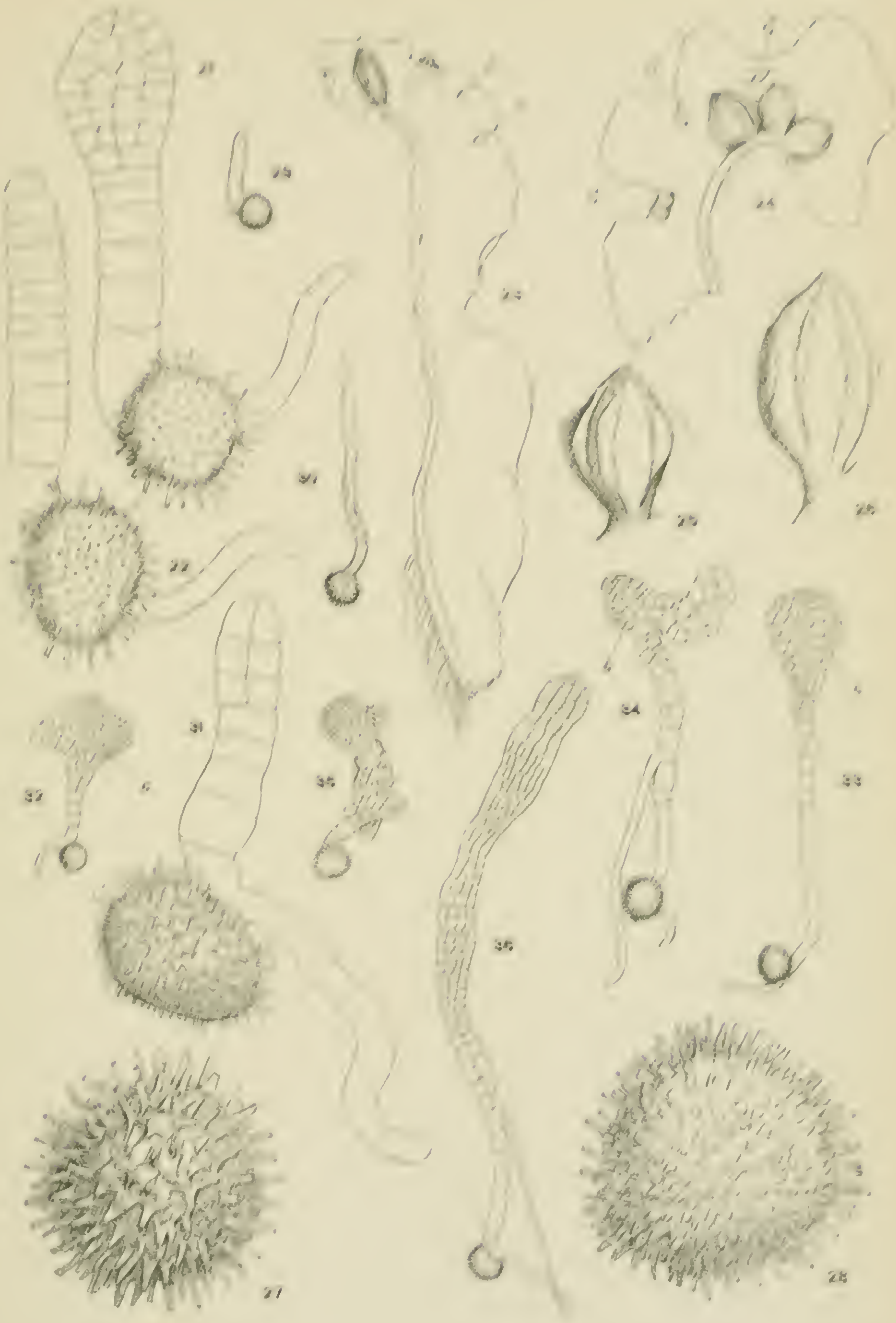
RIELLA AMERICANA Howe & Underw.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21 and 22. RIELLA AMERICANA Howe & Underw.

23-36. RIELLA AFFINIS Howe & Underw.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 35.

THE POLYPORACEAE OF NORTH AMERICA.—
III. THE GENUS FOMES.

By WILLIAM ALPHONSO MURRILL

NEW YORK
1903

[Reprinted from the Bulletin of the Torrey Botanical Club, **30**: 225–232. Ap 1903]

The Polyporaceae of North America.—III. The Genus Fomes

By William Alphonso Murrill

The generic name *Fomes* is usually accredited to Fries, but this author never employed it to designate a genus. In Novae Symbolae, 46, 1851, the genus *Polyporus* is subdivided into *Eupolyporus* and *Fomes*, the latter division being described as follows:

> "Pileus primitus lignoso-induratus (raro molles, plorantes), contextu floccoso intertexto, crusta rigida obductus, azonus, sed demum concentrice sulcatus. *Fungi perennes* (*vulgo stratose*), *reviviscentes, sed stratum annuum vegetum tantum est.*"

In listing species Fries wrote the word *Fomes* in parenthesis after *Polyporus*.

Gillet (Champ. France, **1**: 682. 1878) raised *Fomes* to generic rank and described the group as follows:

> "Hyménium poreux; pores non séparables entr'eux, distincts du chapeau, disposés par couches stratifiées. Espèces ligneuses-subéreuses, stipitées, dimidiées ou résupinées, recouvertes d'une croûte dure, épaisse et st. marquée de zônes annuelles séparées par des sillons concentriques. Champignons vivaces à accroissement indéfini."

Under this genus Gillet lists thirteen species, the first being *F. marginatus*, which is therefore considered its type. Most of the remaining species of *Fomes*, as the term is used in Saccardo's Sylloge, were assigned to this category by Cooke in Grevillea (v. 13 and 14, 1884–85). Karsten was the first to divide generically this large group of perennials, which now comprises a half dozen or more genera, the name *Fomes* being connected with the natural subdivision to which *F. marginatus* belongs. Karsten's name *Fomitopsis*, applied to this subdivision in 1881, unfortunately becomes a synonym of *Fomes*. His names *Ganoderma* and *Elfvingia*, however, hold for other important subdivisions.

Synopsis of the North American Species

1. Context white or yellowish. 2.
   Context flesh-colored, pileus often effused or effused-reflexed, flesh-colored, soon blackening, tubes round, 3–4 to a mm. 1. *F. roseus.*
2. Pileus over 3 cm. broad. 3.
   Pileus less than 3 cm. broad. 8.
3. Pileus encrusted, surface darker than the context. 4.
   Pileus rarely encrusted, surface concolorous with the context. 9.

4. Pileus thick, sulcate, ungulate, rarely applanate. 5.
Pileus at first thin, triangular or lobed, shining reddish-chestnut above, becoming dimidiate, ungulate at the center, and dull brown: spores ovoid, $3.5 \times 5\,\mu$. Pileus attached by a lateral stipe which soon disappears. 7. *F. stipitatus.*
Pileus thin, distinctly zonate, irregular or applanate, crust brown to black: spores ovoid, hyaline, $6 \times 4\,\mu$. 2. *F. annosus.*

5. Surface not soon rimose, older pores not visible. 6.
Surface soon becoming rimose, deeply sulcate, older pores visible in the upper projecting annual layers: pileus exactly ungulate, found only on *Shepherdia.* 4. *F. Ellisianus.*

6. Pores 4–5 to a mm. 7.
Pores 2–3 to a mm.: pileus subtriangular, gray to black, context white to pale cinnamon: spores ellipsoidal, 7–8×6–$7\,\mu$; abundant on *Fraxinus.* 5. *F. fraxinophilus.*

7. Pileus applanate, many times sulcate, horny encrusted, extremely hard in substance; tropical. 6. *F. ligneus.*
Pileus ungulate, applanate when very large, deeply annually sulcate, surface often resinous, bay or black in color; abundant on coniferous trees in temperate regions. 3. *F. ungulatus.*

8. Pileus ungulate, becoming black only at the base, zonate and concentrically sulcate in age, tubes over 0.2 cm. long. 8. *F. Ohiensis.*
Pileus scutellate, uniformly black when quite young, tubes less than 0.2 cm. long, context thinner than tube-layer. 9. *F. scutellatus.*

9. Pileus cylindrical, tubes long, visible at edges of older strata, context friable, becoming bitter; growing on conifers. 10. *F. Laricis.*
Not as above. 10.

10. Pores large, 2 to a mm., becoming reddish when bruised, annual strata separated by thick layers of context; tropical. 13. *F. rubritinctus.*
Pores small, 5–7 to a mm., not changing to reddish when bruised. 11.

11. Tubes less than 2 mm. long each season, context punky, hymenium glistening, not becoming dark in color. 11. *F. populinus.*
Tubes more than 2 mm. long each season, context hard and rather friable, hymenium becoming smoky or brownish, cracking in age. 12. *F. Meliae.*

1. FOMES ROSEUS (Alb. & Schw.) Cooke

Boletus roseus Alb. & Schw. Consp. Fung. 251. 1805.

Polyporus roseus Fr. Syst. **1**: 372. 1821.

Polyporus carneus Nees, Nov. Act. Nat. Curios. **13**: *pl. 3.* 1827.

Fomitopsis rosea Karst. Rev. Myc. **3**: 18. 1881.

Fomes roseus Cooke, Grevillea, **14**: 19. 1885.

Fomes carneus Cooke, Grevillea, **14**: 21. 1885.

This fungus is very widely distributed and does serious injury to various coniferous trees both in Europe and America. Its form varies greatly with the character of the host plant. Besides the names mentioned above, *P. rufo-pallidus* Trog (Flora, **15**: 556.

1832. Fries, Icon. *pl. 186. f. 1*) doubtless refers to the same plant and I have a suspicion that *Polystictus arcticus* Fr. is also a synonym, since plants at Kew collected near Carlton in May, 1858, are only grayish zonate forms of *F. roseus.* The actual types of *P. arcticus* I have not seen.

A few of the collections examined are here listed: Finland (Karsten), Canada (Macoun, Dearness), Maine (Miss White), Newfoundland (Waghorne?), New Hampshire (Minns, Underwood), Ohio (James), New Jersey (Ellis), Colorado (Bethel, Pammell), West Virginia (Nuttall), Washington (Piper), Florida (Calkins), Nebraska (Kennedy), South Carolina (Ravenel), Alabama (Peters), California (McClatchie), Connecticut (Underwood), Georgia (Underwood).

2. FOMES ANNOSUS (Fr.) Cooke

Polyporus annosus Fr. Syst. **1**: 373. 1821. Icon. *pl. 186. f. 2.*

Polyporus serpentarius Pers. Myc. Eur. **2**: 82. 1825.

Polyporus subpileatus Weinm. Fl. Ross. 332. 1836.

Polyporus resinosus Rostk.; Sturm, Deutsch. Fl. **4**: 61–62. *pl. 29.* 1838.

Trametes radiciperda R. Hartig, Wicht. Krankh. Waldb. 62. 1874.

Fomitopsis annosa Karst. Rev. Myc. **3**: 18. 1881.

Fomes annosus Cooke, Grevillea, **14**: 20. 1885.

Heterobasidion annosum Bref. Untersuch. **8**: 154. *pl. 9.* 1889.

Polyporus irregularis Underw. Bull. Torrey Club, **24**: 85. 1897.

Kreiger 121, Romell 13, Sydow 3107, 1108, 504, Allescher & Schnabl 137, 432, Roumeguère 3111, 7248, Rabenhorst 405, de Thümen 106, Kunze 1, Briosi 2, Cavara 324. Sweden (Murrill), Tyrol (Bresadola), California (Harkness), Oregon (McBride), West Virginia (Nuttall), Pennsylvania (Gentry), Alabama (Earle, Baker, Woodward), Florida (Gory).

Many other specimens have been examined, but the above-mentioned are sufficient to show that the plant is of wide distribution. It is particularly injurious to various species of coniferous trees.

3. FOMES UNGULATUS (Schaeff.) Sacc.

Boletus igniarius Scop. Fl. Carn. ed. 2. **2**: 469. 1772. Not *B. igniarius* L. 1753.

Boletus ungulatus Schaeff. Fung. Bav. **4**: 88. *pl. 137, 138.* 1774.

Boletus fulvus Schaeff. Fung. Bav. **4**: 89. *pl. 262.* 1774.

Boletus semiovatus Schaeff. Fung. Bav. **4**: 92. *pl. 270.* 1774.

Boletus marginatus Pers. Obs. **2**: 6–7. 1799.

Boletus pinicola Sw. Vet. Akad. Handl. 88. 1810.

Polyporus marginatus Fr. Syst. **1**: 372. 1821.

Polyporus pinicola Fr. Syst. **1**: 372. 1821.

Fomes marginatus Gill. Champ. Fr. **1**: 683. 1878.

Fomitopsis pinicola Karst. Rev. Myc. **3**: 18. 1881.

Fomes pinicola Cooke, Grevillea, **14**: 17. 1885.

Fomes ungulatus Sacc. Sylloge, **6**: 167. 1888.

A large and widespread species growing abundantly on coniferous trees, such as the hemlock and pine, and found more rarely upon deciduous trees standing near its usual hosts. Beech, elm, maple and birch are known to have been attacked by it in American and European forests where conifers abound. Fresh specimens collected on fir trees in Sweden correspond in all respects with Schaeffer's *B. ungulatus*, so I do not hesitate to use his name. Collections showing the range of this plant are as follows: Saxony (Krieger 13), Sweden (Romell 116, Murrill), Siberia (de Thümen 1906), France (Roumeguère 2205), Bohemia (de Thümen 814), Hungary (Linhart 250, 446), Canada (Macoun), New Hampshire (Minns), New York (Atkinson, Underwood, Murrill), Colorado (Crandall, Cockerell), West Virginia (Nuttall), Michigan (Wood), Maine (Ricker), Virginia (Murrill).

4. FOMES ELLISIANUS Anders.

Fomes Ellisianus Anderson, Bot. Gaz. **16**: 113. *pl. 12.* 1891.

Fomes circumstans Morgan, Jour. Cincinnati Soc. Nat. Hist. **18**: 37. *pl. 1. f. 4.* 1895.

This species was described from plants collected by Anderson in Montana during the summer of 1889. Its only host thus far reported is *Shepherdia argentea* Nutt., on the living trunks and branches of which it is very abundant in the Teton Valley.

Morgan's description is based on a collection in Dakota by T. A. Williams from the same host. His name refers to the half-encircling habit of the plant when it grows upon a branch. The fungus has also been collected in Colorado.

5. FOMES FRAXINOPHILUS (Peck) Sacc.

Polyporus fraxinophilus Peck, N. Y. State Mus. Rept. **35**: 136. 1882.

Fomes fraxinophilus Sacc. Sylloge, **6**: 172. 1888.

Ohio (Morgan, Gentry), Kentucky (Kellerman, Price), Missouri (Demetrio), Kansas (Bartholomew), Nebraska (Bates), Pennsylvania (Martindale), Iowa (McBride), Indiana (Underwood), New York (Peck).

This species is confined to the ash, on which it is very common. It has been confused with *P. fraxineus* (Bull.) Fr. by Cooke and some other mycologists. Anderson's no. 537 in the Parasitic Fungi of Montana was distributed under the name of *P. fraxinophulus* before it was described as *Fomes Ellisianus*.

6. FOMES LIGNEUS (Berk.) Cooke

Polyporus ligneus Berk. Ann. Nat. Hist. **3**: 387. 1839.

Fomes ligneus Cooke, Grevillea, **13**: 119. 1884.

Excellent specimens were collected in Nicaragua by C. L. Smith and in St. Kitts by Britton and Cowell. Plants from Mauritius at Kew bearing this name are specifically distinct from our fungus. *Fomes sulcatus* Cooke from Demarara is nearly allied to *F. ligneus*.

7. **Fomes stipitatus** sp. nov.

A plant of medium size with short evanescent lateral stipe, shining reddish-chestnut crust and broad white thin margin. Pileus exceedingly hard and horny, flat and triangular or somewhat circular when young, becoming dimidiate with ungulate center and thin spreading margin, which is usually lobed and often deeply cleft; hymenium normally plane, but frequently convex because of the upturned margin, 5 × 10 × 3 cm.; surface glabrous, varnished, reddish-chestnut, with numerous shallow concentric furrows, becoming shining black and at length dull smoky-brown; margin broad, flat, glabrous, obtuse, 3 mm. thick, crenate to cleft, sterile portion 0.5 cm. wide, white: context hard, woody, 0.5–1 cm. thick, pale ochraceous, with strands of dark-brown shining horny substance extending from the stipe to the margin in a tree-like fashion: tubes plainly though unevenly stratified, 2–4 mm. long each season, 4–5 to a mm., grayish-brown within, mouths circular, white or very pale yellow, dissepiments thick, obtuse, entire: spores broadly ovoid with attenuate base, light yellowish-brown, smooth, 3.5 × 5 μ: stipe lateral, 1 × 1 cm., cylindrical, equal, glabrous, shining black to dull brown, with substance like the context, apparently absorbed or overgrown as the pileus enlarges.

This very distinct and easily recognized species was collected by C. L. Smith and B. Shimek in Nicaragua during the winter of 1891–92. Its conspicuous varnished surface and lateral stipe suggest at once the genus *Ganoderma*, but more important characters connect it with *Fomes* and I have with some hesitation assigned it to this genus, recalling the fact that *Fomes ungulatus* often has considerable varnish on its surface and that an umbo often has its beginning in a reduced stipe.

8. **Fomes Ohiensis** (Berk.)

Trametes Ohiensis Berk. Grevillea, **1**: 66. 1872.

This plant is unusually small for the genus *Fomes*, making with *F. scutellatus* a rather distinct subgroup. It grows upon rails and dead branches of various deciduous trees. Among collections examined are those from Canada (Dearness), Kansas (Cragin), Michigan (Dennen), Ohio (James), New York (Peck).

9. FOMES SCUTELLATUS (Schw.) Cooke

Polyporus scutellatus Schw. Trans. Am. Phil. Soc. **4**: 157. 1832.

Fomes scutellatus Cooke, Grevillea, **14**: 19. 1885.

This minute species was described by Schweinitz from material collected on *Syringa* in Pennsylvania. It has since been found on alder, witch hazel, sweet gum and other deciduous shrubs and trees. Some of the collections examined are as follows: Pennsylvania (Everhart), Florida (Calkins), Maine (Harvey, Blake), Canada (Macoun), Delaware (Commons), Ohio (James), Alabama (Mell).

10. **Fomes Laricis** (Jacq.)

Boletus Laricis Jacq. Miscel. **1**: 164–203. *pl. 20–21.* 1778. Bull. Herb. France, *pl. 296.* 1786.

B. officinalis Villars, Delph. 1041. 1786.

B. purgans Pers. Syn. 531. 1801.

Polyporus officinalis Fr. Syst. **1**: 365. 1821.

This fungus has been known from ancient times on account of its medicinal properties and is still collected in considerable quantities in the larch forests of Europe and Asia for use in medicine. Single specimens are sometimes found weighing as much as fifteen pounds in the dry state. Many of the older botanists mention this plant. Bauhin (Pinax, 375. 1623) gives a good general description of it under the name "*Agaricum, sive fungus laricis.*" Micheli figures it (Gen. *pl. 61. f. 1.* 1729). Even Dioscorides knew its value. According to Miss Southworth, the substance of the fungus consists mostly of resin-granules about knots of mycelium, containing at times one or more curiously shaped bodies resembling branching bast cells, which grow out from the mycelium. These resin-granules contain the medicinal properties.

The European host of this fungus is the living larch. In America, it has been found also on pine and spruce. Specimens found in Michigan in 1886 on living white pine were used by Calkins and others instead of quinine. MacDougal collected a very handsome specimen on dead spruce in Montana in July, 1901. Macoun also found it on spruce in British Columbia in April, 1889. A recent note in Science from Professor Bessey refers to specimens received by him from Montana and the Yellowstone Park, collected on undetermined species of conifers. Calkins' report of this species in America a dozen or more years ago evidently escaped Professor Bessey's attention.

11. FOMES POPULINUS (Schum.) Cooke

Boletus populinus Schum. Enum. Pl. Saell. **2**: 384. 1803.

Poria obducens Pers. Myc. Eur. **2**: 104. 1825.

Polyporus connatus Weinm. Fl. Ross. 332. 1836. En. Stirp. Petrop. 208. 1837.

Polyporus connatus Fr. Epicr. 472. 1836–1838. Icon. *pl. 185. f. 2.*

Fomes connatus Gill. Champ. France, **1**: 684. 1878.

Fomes populinus Cooke, Grevillea, **14**: 20. 1885.

Finland (Karsten), Bavaria (de Thümen), Germany (Sydow), England (Massee), Sweden (Murrill), Canada (Dearness, Macoun), Georgia (Ellis), Ohio (James, Morgan), Delaware (Commons), New York (Earle, Underwood), Massachusetts (Underwood), Pennsylvania (Herbst), Florida (Martin), New Jersey (Ellis), Missouri (Glatfelter).

The favorite host of this species is the maple, though it is also found on poplar, linden and a few other deciduous trees. Living Norway maples in Sweden were found to be seriously injured by its attacks, and I have noticed it on this and other species of maple used as shade-trees in American cities.

12. **Fomes Meliae** (Underw.)

Polyporus Meliae Underw. Bull. Torrey Club, **24**: 85. 1897.

Described from specimens collected by Underwood on branches of *Melia Azederach* in 1895. It also occurs on *Gleditsia* and *Fraxinus*, as is indicated by the recent Alabama collections of Earle and Baker.

13. **Fomes rubritinctus** sp. nov.

A large perennial plant of many layers, the upper partly dead and discolored, the lower smooth, light-colored and anoderm with large pores, which become dark red when bruised. Pileus corky to woody, dimidiate, convex, 4–12 × 5–15 × 3–10 cm.; surface anoderm, smooth, velvety to the touch, white or pallid, becoming dark brown and roughened with age; margin obtuse, sterile, concolorous: context corky, becoming woody, pallid, 1.5 cm. thick: tubes unevenly stratified, the layers separated by unusually thick cushions of context, 0.5–1.0 cm. long each season, 2 to a mm., isabelline within, becoming umbrinous in the older layers; mouths subcircular or polygonal, edges thin, isabelline, becoming dark red when bruised: spores ovoid to globose, 5–7 μ long, smooth, hyaline, wall of medium thickness, hyphae hyaline.

Collected by C. L. Smith in Nicaragua and distributed as no. 138 of his Central American Fungi.

SPECIES INQUIRENDAE

Fomes geotropus Cooke, Grevillea, **13**: 119. 1884 (*Polyporus geotropus* Cooke, Grevillea, **13**: 32. 1884). This species is allied to *Fomes ulmarius* Fr. It was described from collections in Demerara, but seems to range northward to Mexico, Florida and Alabama. Other doubtful or unknown species are: *Fomes perpusillus* (Pers.) Cooke, *F. extensus* (Lév.) Cooke, *F. aegerita* (Fr.) Cooke, *F. microporus* (Sw.) Cooke, and *F. albogriseus* Peck.

NEW YORK CITY.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 36.

STUDIES ON THE ROCKY MOUNTAIN FLORA.—X.

By PER AXEL RYDBERG

NEW YORK
1903

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Studies on the Rocky Mountain Flora.—X

By Per Axel Rydberg

Corispermum marginale sp. nov.

Annual: stem glabrous, much branched, 2–5 dm. high: leaves narrowly linear, 2–5 cm. long, 1.5–2 mm. wide: spike 3–8 cm. long, rather dense; bracts usually overlapping each other, the lower lanceolate, about 1 cm. long, the upper ovate, 5 mm. long; all more or less acuminate, with a strong midrib and conspicuous scarious margins, slightly pubescent when young or glabrate: fruit about 4 mm. long and 2.5 mm. wide, with a broad wing margin.

This is perhaps most nearly related to *C. hyssopifolium* of the salt marshes of the coast regions, but is taller, more slender, with less fleshy leaves, smaller fruit and more conspicuously scarious-margined bracts. From *C. nitidum* it differs in the broader bracts, denser spikes and larger fruit. It grows in similar localities, viz., in sandy soil, in draws and ravines.

New Mexico: Albuquerque, 1884, *C. L. Herrick* (type in herb. N. Y. Bot. Garden).

Colorado: Huerfano Valley, near Gardner, 1900, *F. K. Vreeland, 657;* Rocky Ford, 1893, *Crandall;* Denver, 1887, *S. M. Tracy*.

Chenopodium Watsoni A. Nelson, Bot. Gaz. **34**: 362. 1902

Chenopodium olidum S. Wats. Proc. Am. Acad. **9**: 95. 1874, mainly. Not Curt.

Annual, rather stout, sparingly farinose, 2–6 dm. high: stem branched, striate and sometimes tinged with red: leaves rather thick; petioles 2–10 mm. long; blades 1–2 cm. long, oval, ovate or oblong, obtuse and occasionally cuspidate-mucronate, dark green and sparingly mealy: inflorescence narrow, dense: flowers 1 mm. in diameter: seed 1.25–1.5 mm. in diameter: pericarp mealy and closely adherent.

Watson's name being preoccupied, I apply Nelson's substitute to this species as it is Watson's *C. olidum* as to the description and most specimens cited. Several specimens given by him belong, however, to the next species, which has been confused with it. Mr. Powell sent some seeds to Elihu Hall. A specimen raised from these seeds and preserved in the herbarium of Columbia University I take as typical *C. Watsoni.*

Chenopodium Wolfii sp. nov.

Chenopodium olidum S. Wats. Proc. Am. Acad. **9**: 95. 1874, partly.

Annual, sparingly mealy: stem erect, 3–4 dm. high, often branched, striate: leaves moderately thick, dark green, only slightly mealy; petioles about 1 cm. long; blades 1–3 cm long, oblong to ovate-lanceolate, entire or rarely slightly hastately toothed, obtuse: inflorescence dense, narrow: flowers small: seeds less than 1 mm., usually .75 mm. in diameter: pericarp thin and easily separated from the seed.

Closely resembling the preceding in habit, but is easily distinguished by the smaller flowers and seed and the separating pericarp. These characters place it nearest to *C. oblongifolium* Nutt., from which it differs in the less mealiness and the smaller seeds.

COLORADO: Twin Lakes, 1773, *John Wolf, 253*, apparently also *258* and *263.*

WYOMING: Wamsutter, 1897, *Aven Nelson, 3671.*

Endolepis ovata sp. nov.

Low, annual, usually less than 1 dm. high: stem branched, straw-colored or pinkish, almost glabrous: leaves subsessile, usually less than 1 cm. long, ovate or lance-ovate, 3-nerved at the base, sparingly mealy: pistillate flowers solitary in the axils of the middle leaves: staminate flowers in small clusters in the axils of the upper leaves or at the end of the branches, otherwise as in *E. Suckleyana* Torr.

In my opinion Dr. Torrey was correct in separating *Endolepis* from *Atriplex.* It is interesting to find a second species of the former genus, which hitherto has been known as monotypic. The original *Endolepis* has narrowly lanceolate leaves, which are thinner and without lateral ribs.

WYOMING: Buffalo, 1900, *Frank Tweedy, 3290* (type in herb. N. Y. Bot. Garden); Wallace Creek, 1898, *Elias Nelson, 4999*; Rock Creek Station, 1881, *L. F. Ward.*

MONTANA: Glendive, 1892, *J. H. Sandberg.*

Cleomella cornuta sp. nov.

Annual: stem straw-colored, 2–3 dm. high, branched below with ascending branches, glabrous throughout: leaves ternate; petioles 1–1.5 cm. long; leaflets 1–2 cm. long, oblong or oblong-oblanceolate, obtuse, mucronate: inflorescence short: pedicels very slender, almost 1 cm. long: sepals yellowish, ovate, cuspidate, less than 1 mm. long: petals light yellow, narrowly oval, clawless, about 3 mm. long: filaments about twice as long: fruit broadly rhombic, broader than long, about 3 mm. long and 4 mm. broad; the corners often produced into short processes: stipe 6–8 mm. long; beak over 1 mm.: seeds about 2.5 mm. long, 1.75 mm. wide, smooth and unmarked.

This is related to *C. oocarpa* and *C. plocasperma*, but has broader leaflets. From the former it also differs in the strongly rhombic pod and from the latter in the broader and unmarked seeds. The type grew at an altitude of 1350 m.

UTAH: Cainsville, 1894, *Marcus E. Jones, 5656* (type in U. S. Nat. Herb.).

Cerastium Earlei sp. nov.

Perennial with a slender branched and stoloniferous rootstock: stems weak, ascending, 2–3 dm. high, viscid-puberulent, branched: leaves oblong or oblanceolate, obtuse, viscid-puberulent, 1.5–3 cm. long, 3–8 mm. wide: inflorescence open; bracts ovate or ovate-lanceolate, not scarious; pedicels 2–2.5 cm. long: sepals lanceolate, acute, sparingly pubescent, scarious on the margins, about 5 mm. long: petals about 1 cm. long or more, fully twice as long as the sepals, not very deeply cleft.

The type number was determined by M. E. Jones as *Cerastium alpinum* near var. *glabratum*, and the other two numbers of the Baker, Earle and Tracy collection are labeled *Cerastium* ———, and *Cerastium arvense oblongifolium*, respectively. The six sheets (two of each number) in the N. Y. Botanical Garden herbarium (except one of number *621*, which represents a luxuriant state) are so alike that it is impossible to refer them to different species. In the size of the flowers, form of the leaves and general habit, the species resembles most *C. alpinum*, but the pubescence is different: in *C. alpinum* long-villous and less viscid, in *C. Earlei* very short and very viscid. The latter grows at an altitude of 2700–3600 m.

COLORADO: Near La Plata P. O., 1898, *Baker, Earle & Tracy*, *472* (type in Herb. N. Y. Bot. Garden); Little Kate Basin, La Plata Mts., *568;* Cumberland Basin, *621.*

Cerastium Leibergii sp. nov.

Perennial with a slender, branched rootstock: stems simple, 4–5 dm. high, sparingly villous and viscid-puberulent; uppermost internode of the stem about 1 dm. long: leaves few and scarcely half as long as the internodes, linear-oblong, 2.5–3 cm. long, 6–7 mm. wide, the lower obtuse, the upper acutish, 1-nerved, thin, puberulent when young, ciliate on the margins: inflorescence viscid-puberulent; bracts lanceolate, 4–8 mm. long, not scarious-margined; pedicels in fruit 2.5–3 cm. long: sepals about 5 mm. long, lanceolate, viscid-pubescent, scarious-tipped and margined: petals scarcely twice as long as the sepals.

This is perhaps most nearly related to the preceding, but differs mainly in the broader, obtuse leaves and smaller flowers. It grows in open *Pinus ponderosa* forests at an altitude of 970 m.

IDAHO: Upper St. Mary's River, 1895, *J. B. Leiberg, 1103* (type in U. S. Nat. Herb.).

Cerastium graminifolium sp. nov.

Perennial with slender branched rootstock: stems 3–5 dm. high, densely short-villous and somewhat viscid, erect; uppermost node of the stem below the inflorescence elongated, 5–10 cm. long: leaves linear-lanceolate, 2–3 cm. long, 3–5 mm. wide, 1-nerved, short viscid-villous, mostly spreading: bracts lanceolate or ovate-lanceolate: pedicels in fruit 2–4 cm. long: sepals narrowly lanceolate, densely viscid-pubescent, only slightly scarious-margined, acute, 5–6 mm. long: petals 12–14 mm. long, cleft ⅓–¼ their length into oblong, obtusish lobes: capsule almost straight, about ⅔ longer than the sepals.

This has gone under the name of *C. arvense*, but differs from the European plant, in the larger flowers, the more villous pubescence and the more acute leaves, which resemble much those of *Alsine graminea.* It grows in rich bottom lands.

WASHINGTON: Pullman, 1897, *Elmer, 177* (type in herb. N. Y. Bot. Garden).

IDAHO: near Lewiston, 1896, *A. A. & E. Gertrude Heller, 3013;* Upper Ferry, Clearwater Ferry, 1892, *Sandberg, MacDougal & Heller, 49.*

Draba sobolifera sp. nov.

A low cespitose perennial, but the leafy stolons often somewhat elongated: basal leaves oblanceolate, obtuse or spatulate, 1–2 cm. long and 3–4 mm. wide, sparingly stellate-villous, thick with indistinct midrib: peduncles 3–6 cm. long, stout, rather many-flowered: petals yellow, obovate, about 4 mm. long, more than twice as long as the rounded sepals: pedicels in fruit 7–8 mm. long: pod ovate, about 6 mm. long, 3–4 mm. wide, finely stellate: style about 5 mm. long.

This species is related to *D. ventrosa* and *D. alpina*. From the former it differs in the longer leaves and the finer and sparser pubescence; from the latter in the more elongated stems, the shorter and stellate pod and the shorter styles. It grows at an altitude of about 2500 m.

UTAH: Marysvale, above timber line, 1894, *Marcus E. Jones*, *5936* (type), *5893c* and *5893az* (all in U. S. Nat. Herb.).

Draba argyrea sp. nov.

A cespitose tufted perennial, with underground horizontal stems; basal leaves obovate, 3–7 mm. long, in dense rosettes, densely and finely stellate, almost silvery; midvein indistinct: peduncles slender, 3–5 cm. long, naked, few-flowered: petals yellow, 3 mm. long, obovate, about twice as long as the ovate sepals: pedicels in fruit 5–8 mm. long: pods lanceolate, 6–7 mm. long, 2.5–3 mm. wide, minutely stellate: style about 1 mm. long.

This species resembles somewhat *D. oligosperma* in general habit and flowers, but the leaves are shorter and broader, more decidedly stellate and without the strong midrib, and the pod is longer. It also reminds one of *D. ventrosa* but is a more delicate plant with finer pubescence and longer pods. The type grew at an altitude of about 3000 m.

IDAHO: Rock crevices, Sawtooth Mountains, head of Pettit Lake, July, 1895, *L. F. Henderson*, *3538* (type in U. S. Nat. Herb.).

Draba uncinalis sp. nov.

Small cespitose and pulvinate perennial: flowering stems scapiform, 2–3 cm. high, sparingly stellate, leafless; basal leaves in dense tufts, thick, rounded obovate, 3–4 mm. long, sparingly stellate, with indistinct midrib: inflorescence corymbiform, few-flowered; pedicels in fruit 4–5 mm. long: pod ovate, 3–4 mm. long and 3 mm. wide, glabrous or nearly so: style about 0.5 mm. long.

A small plant characterized by the short pod, found otherwise only in two North American species, viz., *D. andina* and *D. oligosperma;* but in both of those species the leaves have strong midribs and are less stellate. In habit it resembles most *D. nivalis*, but that species has a different pod. It grows at an altitude of 3500 m.

Utah: Marysvale, Tate Mine, 1894, *M. E. Jones, 5940am* (type in U. S. Nat. Herb.).

Lesquerella Utahensis sp. nov.

A tufted perennial: stems ascending, 5–10 cm. (seldom 15 cm.) high; basal leaves 3–4 cm. long, petioled; blades oval or obovate, densely and finely stellate; stem-leaves smaller, oblanceolate or spatulate: petals yellow, about 8 mm. long, with cuneate blades, ½ longer than the oblong sepals: pedicels in fruit ascending, 5–10 mm. long: pod almost spherical or slightly transversely flattened, 3–4 mm. wide, finely stellate: style 4–5 mm. long, much longer than the pod.

This species is related to *L. Wardii, i. e.*, it has the same habit and pubescence and the pod is as in that species somewhat thicker than broad; but the latter is shorter, rounder, neither elongated nor acute at the apex. *L. Utahensis* grows at an altitude of 2000–3500 m.

Utah: American Fork Cañon, 1880, *Marcus E. Jones, 1354* (type in herb. N. Y. Bot. Garden); Friser, 1880, *1810;* Marysvale, 1884, *5375e, 5958n;* Irelands Ranch, Salina Cañon, *5441;* Cañon above Tropic, *5312d.*

Stanleya runcinata sp. nov.

Stem stout, glabrous: basal leaves about 2 dm. long, lanceolate in outline, runcinately divided, softly pubescent with long white hairs; lobes broadly triangular or the lowest ones oblong: stem-leaves ovate to oblanceolate, more glabrous: raceme 1–3 dm. long, many-flowered: sepals linear, about 1 cm. long and 1 mm. wide, light yellow, glabrous: petals about ¼ longer; blades oblanceolate, about ⅔ as long as the glabrous claws: filaments glabrous, about twice as long as the sepals: pods almost erect and straight, 6–7 cm. long, 1.5 mm. wide, on spreading pedicels about 1 cm. long.

This species is perhaps most closely related to *S. pinnata*, but easily distinguished by the lobing of the basal leaves, the straight pods, the oblanceolate blades of the petals and the glabrous filaments.

IDAHO (?): 1896, *Henderson* (type in U. S. Nat. Herb.).

Thelypodium ovalifolium sp. nov.

Perennial, perfectly glabrous: stems terete, 3–5 dm. high, ascending: earliest basal leaves about 5 cm. long, petioled with broadly oval blades, glabrous, entire, obtuse; the later ones oblanceolate; stem-leaves sagittate, 2 cm. long, thick, sessile and clasping, with short rounded basal lobes: inflorescence elongated: sepals oblong, 3 mm. long: petals about 5 mm. long with spatulate blades and slender claw: pedicels in fruit 4–5 mm. long, spreading: pods ascending, 1–2 cm. long and about 1 mm. wide, somewhat torulose.

This species is perhaps most nearly related to *T. paniculatum*, but differs in the short pods and the broad basal leaves.

UTAH: Panguitch Lake, 1894, M. E. Jones, *6015c* (type in U. S. Nat. Herb.).

Lepidium Georginum sp. nov.

Apparently biennial, cespitose from a slender taproot, 1–2 dm. high: stems hirsute with short spreading hairs: basal leaves 1–5 cm. long, deeply pinnately divided with ovate lobes; stem-leaves similar or the upper oblanceolate and entire; all more or less pubescent: inflorescence short: petals spatulate, slightly exceeding the sepals: pods pubescent, rounded oval, 4 mm. long, broadly winged above, forming at the apex two broadly ovate obtuse lobes, over 0.5 mm. long.

This species is in habit nearest *L. Wrightii* with which it has been confused; but it is less hairy and the pods are those of *L. dictyotum*.

UTAH: "Southern Utah," 1874, *C. C. Parry*, *19* (type in herb. Columbia University); 1877, *E. Palmer*, *40;* St. George, 1880, *M. E. Jones*, *1614;* Milford, *1821* in part; 1894, *5110f*.

Thysanocarpus trichocarpus sp. nov.

Annual, perfectly glabrous, except the fruit, 1–3 dm. high: stem terete, branched: lower leaves oblanceolate or oblong, sinuately dentate, thick and somewhat glaucous; uppermost leaves linear or linear-lanceolate, entire: racemes often 1 dm. long: petals slightly over 1 mm. long; blades broadly spatulate: pedicels in fruit about 5 mm. long, recurved: pod nearly orbicular, about 4 mm. wide, short-pubescent: wing-margins crenate or lobed, not fenestrate: style scarcely exceeding the wing-margin.

UTAH: Silver Reef, 1894, *M. E. Jones, 5163b*, in part (type in U. S. Nat. Herb.), *5149d* and *5139d*.

Trifolium lividum sp. nov.

Perennial, densely cespitose and tufted: branches of the caudex short and covered by the remnants of the leaf-bases and scarious stipules; free portion of the latter subulate-filiform: petioles 4–15 cm. long, slender, glabrous; leaflets linear-lanceolate or oblanceolate, very acute at both ends or cuspidate at the apex, 3–4 cm. long, glabrous above, sparingly appressed hairy beneath, green, entire-margined: peduncles 1–1.5 dm. high, sparingly appressed hairy: heads nearly 2 cm. in diameter; bracts linear-subulate to almost filiform, longer than the calyx-tube, glabrous, slightly if at all scarious-margined: calyx-tube 2.5–3 cm. long; teeth subulate-filiform, 4–5 mm. long: corolla about 12 mm. long, light purple with a darker keel.

This species is nearest to *T. dasyphyllum*, but is a larger, more glabrous and greener plant, and with much larger and narrower bracts. It grows at an altitude of about 3000 m.

COLORADO: Graymount, 1895, *P. A. Rydberg, 2442* (type in herb. N. Y. Bot. Garden); Alpine Tunnel, 1897, *C. L. Shear.*

Trifolium pedunculatum sp. nov.

Perennial, with a somewhat cespitose base: stems 2–4 dm. high, rather slender, striate, glabrous or with a few appressed hairs: stipules 2–3 cm. long, lanceolate, ½ or ⅔ of their length adnate to the petioles, denticulate: petioles 4–6 cm. long, slender; leaflets 3, oblanceolate to linear, acute, finely denticulate, 2–3.5 cm. long: peduncles 1 dm. or more long: heads 15–18 mm. in diameter, not bracteate: flowers subsessile, 10–12 mm. long, in fruit not reflexed: calyx-tube 2 mm. long, glabrous below, pubescent towards the throat; calyx-teeth subulate, the lower 3–3.5 mm. long: corolla purple.

This species is nearest to *T. longipes*, but differs in the smaller purple flowers and the calyx which is glabrous below.

IDAHO: Long Valley, 1895, *L. F. Henderson, 3096* (type in U. S. Nat. Herb.); near Sawtooth, 1896, *B. W. Evermann, 592.*

Lotus longebracteatus sp. nov.

Perennial, cespitose, decumbent: stems 2–3 dm. long, diffusely branched, grayish strigose: leaves thick, grayish strigose with a distinct rachis ; leaflets 4, linear to oblong or of the lowest leaves obovate, 1–1.5 cm. long or the lower shorter : peduncles 4–5 cm. long, 1–2-flowered ; bracts linear, about equalling the calyx : calyx strigose, its tube and teeth each about 4 mm. long ; the latter subulate : corolla about 14 mm. long, strongly curved upwards, the banner much exceeding the wings and keel : pod linear, straight, 2.5–3 cm. long, pubescent.

This is in some respects intermediate between *L. rigidus* and *L. Wrightii*, differing from the former in the narrower leaflets, in the shorter peduncles, longer bracts and narrower calyx-teeth and from the latter in decumbent habit, leaves with a distinct rachis and elongated peduncles.

UTAH : "South Utah," 1877, *Dr. E. Palmer, 94* (type in U. S. Nat. Herb.).

Lupinus depressus sp. nov.

Perennial, cespitose : stems decumbent, 1–2 dm. long, appressed silvery silky pubescent : petioles slender, 5–7 cm. long, also silvery silky ; leaflets about 7, oblanceolate, usually obtusish, 1.5–2 cm. long, densely appressed silvery canescent ; stipules subulate : racemes short, slightly exceeding the leaves ; bracts lanceolate, short, deciduous : flowers 8–9 mm. long : calyx long-villous ; lips ovate-lanceolate ; the lower about ⅓ longer than the upper : corolla light bluish-purple ; banner glabrous, slightly shorter than the wings.

Being perhaps most nearly related to *L. minimus*, it differs from that in the decumbent or spreading leafy stem and more silky pubescence. It grows in gravel on dry mountain slopes, at an altitude of about 1750 m.

IDAHO : Divide between St. Joe and Clearwater River, 1895, *John B. Leiberg, 1201* (type in U. S. Nat. Herb.) ; Lo-Lo Trail, 1880, *S. Watson, 80*.

Lupinus Evermannii sp. nov.

Perennial and densely cespitose : the numerous stems about 1.5 dm. high, slender, erect or ascending, leafy, appressed hairy : petioles 2–4 cm. long, also appressed hairy ; leaflets oblanceolate to linear-oblanceolate, 1–2.5 cm. long, densely canescent on both sides with long appressed hairs ; stipules lanceolate, acuminate : raceme very short-peduncled, dense and short ; bracts lanceolate, short, deciduous : flowers 6–7 mm. long ; pedicels and calyx densely pubescent with spreading hairs ; lips of the latter ovate-lanceolate, the lower about ⅓ longer than the upper: corolla purplish-blue; banner with a light spot, glabrous.

This species is nearest related to *L. holosericeus*, but the corolla is lighter and the pubescence of the calyx is spreading. It is also lower and more cespitose, resembling more *L. candicans* in habit, but has much smaller flowers.

IDAHO: Near Sawtooth, 1896, *B. W. Evermann, 533* (type in U. S. Nat. Herb.).

Lupinus Jonesii sp. nov.

Perennial, very stout: whole plant yellowish-green: stem over 1 mm. high, densely pubescent with two kinds of hairs, viz., a short pubescence and long spreading silky hairs; petioles about 5 cm. long, also pubescent with spreading hairs; leaflets 7–9, oblanceolate, densely appressed, yellowish hairy on both sides, 4–7 cm. long; stipules setaceous, deciduous: raceme long and dense, many-flowered; bracts subulate-filiform, much exceeding the buds; pedicels and calyx densely hairy with short spreading hairs: flowers about 16 mm. long: lips of calyx ovate-lanceolate; the lower about ⅓ longer than the upper: corolla white; the banner with a faint brownish spot; keel purple-tipped.

This species is nearest related to *L. leucophyllus*, but is less densely pubescent, the flowers are larger and in the type sheet whitish and the bracts are much longer. It grows at an altitude of about 4200 ft.

UTAH: Silver Reef, May 3, 1894, *Marcus E. Jones, 5143* (type in U. S. Nat. Herb.).

Lupinus adscendens sp. nov.

Perennial: stem 4–6 dm. high, appressed silky, leafy: petioles 5–10 cm. long, ascending, also appressed silky; leaflets about 7, linear-oblanceolate, 4–5 cm. long, acute, appressed silky on both sides but green; stipules subulate: racemes elongated, narrow; pedicels strongly ascending, rather long hairy: flowers about 12 mm. long: calyx grayish silky; the lower lip slightly longer than the upper: bract linear-subulate, much longer than the buds, almost equalling the calyx in length: corolla dark bluish-purple; the banner glabrous with a lighter spot.

This species is related to *L. laxiflorus*, but the calyx is not spurred and the bracts are much longer.

WYOMING: Headwaters of the Tongue River, 1898, *F. Tweedy, 129* (type in herb. N. Y. Bot. Garden); Head of Big Goose Creek, 1893, *F. Tweedy, 13*.

Lupinus argentinus sp. nov.

Perennial, densely appressed white-silky throughout: stem 4–6 dm. high: petioles 5–7 cm. long; stipules lanceolate-subulate; leaflets about 7, oblanceolate, densely silky on both sides, 3–5 cm. long, conduplicate and with strongly curved back: inflorescence rather short and dense; bracts ovate-lanceolate, short, deciduous: flowers about 1 cm. long: calyx and pedicels densely white-silky, spurred at the base; lower lip lanceolate, about one third longer than the upper: corolla bluish-purple; banner pubescent on the back, about as long as the wings: pods oblong, densely pubescent, about 3 cm. long and 5–6-seeded.

This species is nearest to *L. argophyllus*, but differs in the denser and whiter pubescence, the broader curved leaflets and the more pubescent banner. It grows at an altitude of 1200–2200 m.

Utah: Near Reno, 1900, *S. G. Stokes* (type in herb. N. Y. Bot. Garden); Provo River, 1881, *M. E. Jones, 2169;* Salt Lake City, 1869, *S. Watson, 227.*

Lupinus comatus sp. nov.

Perennial, somewhat cespitose: stem about 3 dm. high, pubescent with long spreading silky hairs: petioles of the basal leaves about 1 dm. long, also pubescent with spreading hairs, leaflets narrowly oblanceolate, acute, 2.5–4 cm. long, green, pubescent on both sides; stem-leaves similar, but with shorter petioles; stipules linear lanceolate, long-acuminate: raceme short and dense, short-peduncled; bracts lanceolate-subulate, equalling or exceeding the buds; pedicels and calyx densely pubescent with spreading hairs; lips almost equal, ovate-lanceolate: flowers 8–10 mm. long: corolla bluish-purple, rarely white; banner slightly shorter than the broad wings.

The species is somewhat related to *L. laxiflorus* but the calyx is not spurred, the raceme short and dense, the flowers larger and the pubescence of the stem and petioles long and spreading.

Colorado: Lake City, 1878, *F. N. Pease* (type in herb. Columbia University); Gunnison Co., 1895, *C. L. Pollard* (?) (U. S. Nat. Herb.).

Lupinus maculatus sp. nov.

Perennial, strict: stem 4–6 dm. high, finely appressed puberulent: petioles short, 2–4 cm. long, almost glabrous; leaflets 5–7, those of the lower leaves obovate-oblanceolate, mucronate; those of the upper oblanceolate and acute, sparingly appressed hairy beneath, glabrous above, 3–5 cm. long: inflorescence short-peduncled and dense; bracts ovate-lanceolate, acuminate, deciduous; the short pedicels and the calyx densely pubescent with short spreading hairs; lips of the calyx ovate-lanceolate, the lower slightly longer than the upper: flowers 10–12 mm. long; banner light purple with a dark spot, glabrous, much shorter than the white or purple-tinged wings; keel white with purple tip: pods oblong, densely pubescent, 2.5–3 cm. long, 4–5-seeded.

The type was labeled *Lupinus parviflorus*, to which it is somewhat related, but the raceme is much denser, the flowers larger, the corolla of a different color and with a very dark spot.

UTAH: P. V. Junction, Wasatch Mts., 1883, *M. E. Jones* (type in herb. N. Y. Bot. Garden and duplicates in U. S. Nat. Herb.); Woods Class, 1882, *M. E. Jones.*

Lupinus pulcherrimus sp. nov.

Perennial, more or less cespitose: stems 3–6 dm. high, sparingly appressed hairy, leafy: petioles 3–6 cm. long, also appressed hairy or glabrate; leaflets 7–9, linear-oblanceolate, acute, appressed silky on both sides, but green; stipules lanceolate, subulate: raceme more or less elongated and rather dense, short-peduncled; bracts lanceolate, short-acuminate, shorter than the buds, deciduous: pedicels and calyx grayish silky; lips of the latter lanceolate, the upper somewhat shorter: flower about 1 cm. long: corolla dark purple; banner with a light spot, pubescent on the back: pods broadly oblong, 3–3.5 cm. long, 5–6-seeded.

This species is also related to *L. laxiflorus*, but the raceme is denser, the calyx scarcely spurred, and the flowers are larger. It also resembles *L. pseudoparviflorus*, but in that species the leaves are glabrous above and the calyx also spurred. From *L. adscendens* it differs in the spreading flowers and the short bracts.

WYOMING: Battle, Continental Divide, 1901, *F. Tweedy, 4215* (type in herb. N. Y. Bot. Garden); Headwaters of Tongue River, 1898, *Tweedy, 130;* Big Horn Mountains, 1899, *Tweedy, 2365;* La Barge, Uintah County, 1894, *E. Stevenson, 158.*

MONTANA: Divide between McDonald and Comas Lakes, 1901, *F. K. Vreeland, 996;* Little Belt Pass, 1896, *P. A. Rydberg, 3318; J. H. Flodman, 620;* Baltic, 1900, *E. V. Wilcox, 58.*

Lupinus laxus sp. nov.

Perennial and somewhat cespitose: stem 4–6 dm. high, slender, sparingly appressed, silky: petioles 3–12 cm. long, appressed silky; leaflets 7–9, linear or linear-oblanceolate, 3–4 cm. long, green, but appressed silky on both sides; stipules subulate: racemes slender and lax; bracts lanceolate, short-acuminate, not longer than the buds: pedicels and calyx rather long, hairy: flowers about 8 mm. long: calyx not spurred; lips ovate, the upper slightly shorter: corolla light bluish-purple; banner broad, somewhat shorter than the wings.

This species is closely related to *L. laxiflorus*, but the flowers are smaller and lighter and the calyx is not spurred. It grows at an altitude of about 2000 m.

MONTANA: Forks of the Madison, 1897, *Rydberg & Bessey, 4442* (type in herb. N. Y. Bot. Garden), also *4443a.*

WYOMING: La Barge, Uintah Co., 1894, *E. Stevenson, 157* (somewhat more hairy than the type).

Lupinus leucanthus sp. nov.

Perennial, about 6 dm. high: stem minutely strigose, leafy: petioles about 6 cm. long, almost glabrous; leaflets 5–7, narrowly oblanceolate, 4–5 cm. long, acute or short-acuminate, glabrous above, sparingly appressed hairy beneath; stipules subulate: raceme lax; bracts lanceolate, acuminate, about equalling the pedicels, 6–8 mm. long: pedicels and calyx appressed short-hairy; lower lip of the latter linear-lanceolate, about ⅓ longer than the ovate upper one: corolla white with a brownish spot on the banner; the latter glabrous and almost equalling the wings.

This species is nearest related to *L. Scheuberae*, but differs in the larger white flowers and the longer upper lip of the calyx. The type sheet bears the name *Lupinus barbiger* Wats., but the plant is not at all related to that species.

UTAH: Springdale, 1894, *Marcus E. Jones, 5249e* (type in U. S. Nat. Herb.).

Pachylophus macroglottis sp. nov.

Acaulescent or nearly so: leaves 8–15 cm. long, tapering into a margined petiole; blades broadly oblanceolate, acute, sinuate-dentate, sparingly puberulent, and villous ciliate on the margins and the veins, very thin: hypanthium very long and slender, 12–14 cm. long, sparingly villous or nearly glabrous, gradually widening into a funnelform throat, which at the insertion of the sepals, petals and stamens, is about 1 cm. in diameter: sepals lanceolate, gradually long-acuminate, about 5 cm. long and much exceeding the broadly obcordate petals, which are about 3.5 cm.

long and fully as wide, very thin, at first white but turning pink in age: filaments about 2.5 cm. long: anthers versatile, 1.5 cm. long and 2 mm. wide: style exserted; lobes of the stigma about 5 mm. long: capsule with rather strong sinuately lobed ridges.

This species differs from *P. caespitosum* (Nutt.) Raimann in the villous ciliate leaves, the longer hypanthium which is much broader at the throat than in any of the other species, the longer sepals which much exceed the petals in length, and the less tubercled ridges of the pod. It grows in cañons at an altitude of 1500–2800 m.

Colorado: Tributaries of Turkey Creek, 1900, *Rydberg & Vreeland, 5857* (type).

Pachylophus exiguus (A. Gray) Rydb. nom. nov.

Oenothera exigua A. Gray, Pl. Fendl. 1849.

This species was merged into *P. caespitosus* by Dr. Watson; but it is perfectly distinct. The plant is nearly always caulescent with a stem 0.5–2 dm. high, the leaves and hypanthium are villous as in the preceding species, but still more so, the hypanthium is fully as long, but less widened at the throat, and the angles of the pod with more prominent sinuately lobed crests than in *P. caespitosus*. This species is represented in the New York herbaria by the following specimens:

Colorado: Rocky Ford, 1891, *C. S. Crandall;* Mesas near Pueblo, 1900, *Rydberg & Vreeland, 5858;* Rocky Ford, 1900, *G. Osterhout*, 2085.

New Mexico: White Mountains, 1897, *E. O. Wooton, 659.*

Arizona: Walnut Cañon, 1898, *MacDougal, 341.*

Androsace puberulenta sp. nov.

A puberulent rosulate annual: leaves oblanceolate, 1–3 cm. long, acute, entire or sinuately denticulate, densely puberulent: peduncles several, 3–10 cm. long: bracts narrowly lanceolate, 3–4 mm. long: pedicels 1–5 cm. long, spreading, densely puberulent: calyx 3–4 mm. long, cleft to the middle; tube glabrous, turbinate; lobes lanceolate, strongly keeled, densely puberulent, in fruit much exceeding the short capsule: corolla white, about equalling the calyx.

This species is in habit intermediate between *A. subumbellata* and *A. diffusa*, but differs from both in the densely puberulent pedicels and calyx-lobes. In both specimens mentioned the calyx-lobes are of the length and shape of the valves of the maturing capsules, while in *A. puberulenta* they are much longer. The range of the species extends from Manitoba and the Mackenzie River south to New Mexico. The type was collected in southern Colorado near Veta Pass, 1900, *Rydberg & Vreeland, 5772* (N. Y. Bot. Garden).

Gilia subacaulis sp. nov.

Apparently biennial with a slender taproot : stem less than 1 dm. high, almost leafless, diffusely branched, glandular-puberulent : leaves almost all basal, 1.5–3 cm. long, pinnatifid with triangular to oblong divisions, glandular-puberulent, or slightly white-villous when young : inflorescence open ; pedicels 2–4 mm. long : calyx 2–2.5 mm. long, puberulent, scarious between the green ribs ; lobes lanceolate, about half as long as the tube, acute : corolla 4–6 mm. long, funnelform, fully twice as long as the calyx, its tube distinctly exserted : stamens included : capsule rounded ovoid, acute, 4–5 mm. long.

This is related to *S. inconspicua*, but differs in the almost leafless stem, and the smaller corollas which have a comparatively longer tube. The following specimens belong here.

WYOMING : Point of Rocks, 1901, *Merrill & Wilcox, 607* (type in Herb. N. Y. Bot. Garden).

UTAH : St. George, 1877, *Palmer, 328 ;* 1874, *Parry, 199.*

COLORADO : Gunnison River, 1894.

Mertensia subpubescens sp. nov.

Mertensia Sibirica Rydb. Mem. N. Y. Bot. Gard. **1** : 335. 1901 ; mainly.

Perennial with a thick rootstock : stem simple, stout, 6–10 dm. high, glabrous throughout : lower leaves petioled, the upper sessile ; blades broadly lanceolate, 5–10 cm. long, tapering at both ends, thin, glabrous or nearly so above, short-pubescent beneath and ciliate on the margin : inflorescence a rather many-flowered short panicle ; pedicels slightly strigose : calyx-lobes oblong-linear, obtuse, ciliate on the margin, 2–2.5 mm. long, about ¼–⅓ as long as the corolla-tube : corolla about 12 mm. long ; the tube only slightly longer than the limb : filaments broad and dilated, broader than the anthers and about half as long.

This is perhaps nearest related to *M. ciliata*, but is easiest distinguished by the pubescent lower surface of the leaves. It grows along streams at an altitude of 2000–2200 m. The following specimens from Montana belong here:

MONTANA: Spanish Basin, 1897, *Rydberg & Bessey, 4876* (type in herb. N. Y. Bot. Garden); near Indian Creek, *4872;* Bridger Mountains, *4875;* Mystic Lake, 1895, *C. L. Shear, 3076;* Deer Lodge County, 1901, *Mrs. Emma W. Scheuber, 42;* Basin, 1902, *Kelsey.*

Heliotropium spathulatum sp. nov.

Heliotropium curassavicum Hook. Fl. Bor. Am. **2**: 81. 1840. Not L.

? Heliotropium curassavicum obovatum DC. Prod. **9**: 538. 1845. Not *H. obovatum* D. Don.

A glabrous, more or less glaucous, fleshy perennial with ascending more or less branched stems, 3–5 dm. high: leaves spatulate, fleshy, indistinctly nerved, 2–5 cm. long, obtuse or rounded at the apex, tapering at the base and the lowermost petioled: inflorescence branched into 2–5 racemes; these often starting from one point at the end of the common peduncle: calyx about 3 mm. long, cleft to the middle; its lobes ovate-lanceolate, acute: corolla white or slightly tinged with blue, 6–8 mm. long; the limb of about the same width: nutlets 2.5–3 mm. long, scarcely rugose.

This is the common plant of the Rocky Mountain region that has been known as *H. curassavicum* L., but has much broader leaves, more than twice as large flowers and larger fruit than the cosmopolitan plant found on our eastern seaboard and in the southern states. It is probably the same as the plant collected by Douglas in the Blue Mountains of Oregon and briefly described in the places cited above. Hooker states that in the Blue Mountains were the only places where Douglas found *H. curassavicum.* In the Columbia herbarium there is a specimen, labelled: "California, *Douglas.*" If this specimen is one of those collected in the Blue Mountains and described by Hooker and DeCandolle, the synonyms cited above should be excluded; for the specimens evidently belong to the short-leaved and smaller-flowered form of *H. curassavicum* common on the Pacific coast and described by Willdenow under the name *H. chenopodioides.*

H. spathulatum is fairly common in meadows throughout the Rocky Mountain region and the great plains from Assiniboia and Washington to Iowa, New Mexico, Chihuahua and California. The type was collected at Great Falls, Montana, 1890, *R. S. Williams, 542* (in herb. N. Y. Bot. Garden).

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SOME GENERIC SEGREGATIONS

By P. A. RYDBERG

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Some Generic Segregations

By P. A. Rydberg

(With Plates 13 and 14)

The concept of a genus may vary among botanists as well as among zoölogists. To some a genus is an aggregate of all forms of organisms which can be included within a certain artificial description or diagnosis; to others it is a natural group of closely related species or forms and may be modified, extended or limited as soon as these forms become better known. It is unnecessary to state that the former view nowadays has very few advocates, for nature was never made to follow the narrow concepts of man. A systematist who holds the second view, tries first to find what species are closely related, and when these are brought together, he tries to draw a diagnosis of the genus. The limitation of a genus depends naturally upon the personal views of the taxonomist. What is a single genus to one botanist may to another constitute half a dozen or more good genera, *i. e.*, groups of related species. It matters little how broad or narrow concepts we have of a genus, if only we are consistent and in the same family or tribe designate as genera equivalent natural groups of related species; *i. e.*, not making in one case the limits of a genus too large and in another too narrow.

I. An inconsistency of this kind exists, I think, in the usual treatments of the family Melanthaceae. *Chrosperma* and *Stenanthium*, *Melanthium* and *Veratrum*, are separated by rather trifling characters, while in *Zygadenus* are included species of no closer relationship. If we keep as distinct all of the first four genera, we must, if consistent, divide *Zygadenus* into at least three genera. Briefly these may be distinguished as follows:

Plant with a rootstock; each petal and sepal with two glands.	*Zygadenus.*
Plant with a bulb; each petal and sepal with a single gland.	
Ovary wholly superior; gland obovate or semi-orbicular.	*Toxicoscordion.*
Ovary partly inferior; gland obcordate.	*Anticlea.*

ZYGADENUS Michx. Fl. Bor. Am. **1**: 213. 1803

This genus was established on a single species *Z. glaberrimus* and the generic name will go with it. This species differs from all that later have been included in the genus, in having a thick elongated rootstock instead of a bulb and two distinct round glands on each of the petals and sepals. As far as I know the genus consists of only one species.

Toxicoscordion gen. nov.

Glabrous, more or less poisonous perennials with narrow linear conduplicate leaves, yellowish racemose or paniculate flowers and membrane-coated bulbs. Flowers perfect (in one species described as polygamous, but as far as I know erroneously so). Petals and sepals bearing a single obovate or semiorbicular gland at or above the base of the blade, in most species more or less clawed. Ovary wholly superior. Stamens (except in one species) more or less adnate to the base of the petals and sepals; anthers subreniform, confluently one-celled. Capsule 3-celled, 3-beaked, septicidal. Seeds numerous.

The first species known belonging to this group was published under the name *Amianthium Nuttallii* A. Gray; but as this is somewhat aberrant from the general type of the genus, I have selected one of the most common species, *Zygadenus intermedius*, as the type. The following species belong here:

1. **T. intermedium**; *Z. intermedius* Rydb.*
2. **T. venenosum** (S. Wats.); *Z. venenosus* S. Wats.
3. **T. gramineum**; *Z. gramineus* Rydb.
4. **T. acutum**; *Z. acutus* Rydb.
5. **T. falcatum**; *Z. falcatus* Rydb.
6. **T. paniculatum** (Nutt.); *Helonias paniculata* Nutt.
7. **T. Nuttallii** (A. Gray); *Amianthium Nuttallii* A. Gray.

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* For citations and synonyms, see Bull. Torrey Club, **27**: 534–538. 1900.

8. **T. Fremontii** (Torr.); *Anticlea Fremontii* Torr. Pac. R. R. Rep. **4**: 144. 1856; *Zygadenus Fremontii* Torr.; S. Wats. King's Exped. **5**: 343. 1871.

ANTICLEA Kunth.

This genus was established on *A. Sibirica* and *A. glauca* with *A. Mexicana* added as a doubtful species. *A. Sibirica*, the first one mentioned, must be regarded as the type. It differs somewhat from our American species, especially in the narrow somewhat recurved petals and sepals and the narrow glands, but these differences are rather unimportant and do not warrant any generic separation. The genus is characterized by a membranous coated bulb, linear glabrous leaves, greenish or yellowish-white flowers, withering persistent petals and sepals, which are adnate to the base of the ovary and bear a single obcordate gland; free stamens and a partly inferior ovary. The species are:

1. A. SIBIRICA (L.) Kunth, Enum. **4**: 191. 1843; *Melanthium Sibiricum* L. Sp. Pl. 339. 1753; *Zygadenus Sibiricus* Kunth, Enum. **4**: 192, as synonym.
2. **A. chlorantha** (Richards.); *Z. chloranthus* Richardson, Frankl. Journ. 736. 1821; *Z. commutatus* Schultes, Syst. **7**: 1560. 1830; *Z. glaucus* Nutt. Jour. Acad. Phila. II. **7**: 56. 1834; *Anticlea glauca* Kunth, Enum. **4**: 192. 1843.
3. **A. virescens** (H.B.K.); *Helonias virescens* H.B.K. Nov. Gen. & Sp. **1**: 267. 1816; *A. Mexicana* Kunth, Enum. **4**: 193. 1843; *Z. Mexicanus* Hemsl. Biol. Cent. Am. **3**: 382. 1885.
4. **A. elegans** (Pursh); *Z. elegans* Pursh, Fl. Am. Sept. 241. 1814.
5. **A. Coloradensis**; *Z. Coloradensis* Rydb. Bull. Torrey Club, **27**: 534. 1900.
6. **A. porrifolia** (Greene); *Z. porrifolius* Greene, Bull. Torrey Club, 8: 123. 1881.

II. Another segregation needed, I have found in the genus *Rubus*. If *Dalibarda* is to be held distinct from that genus and *Duchesnea* from *Fragaria*, etc., certain species have to be removed from *Rubus* as now understood, as both in general habit and the structure of the fruit they are so unlike the rest of the species. The segregated genera would be distinguished as follows:

Styles club-shaped; stigmas slightly 2-lobed; receptacle flat; shrubs, unarmed, with shreddy bark and digitately ribbed maple-like leaves.
  Drupelets capped by hard hairy cushions; styles glabrous; erect shrubs. *Rubacer.*
  Drupelets without cushions; styles hairy; prostrate or reclining vines. *Oreobatus.*
Styles filiform, glabrous; stigmas usually capitate; receptacle hemispherical, conical or nipple-shaped; drupelets without cushions; leaves in most species pinnate and stem in most prickly. *Rubus.*

Rubacer gen. nov.

Unarmed shrubs with more or less shreddy bark, more or less glandular above. Leaves petioled, simple, digitately ribbed and lobed, with acute or acuminate lobes and cordate bases, resembling the leaves of certain maples. Flowers showy, in small panicles: sepals ovate with long slender acuminations: petals pink or white, oval or rounded: pistils numerous: receptacle flat or nearly so: drupelets numerous, capped with a dry, rather hard, finely and densely pubescent cushion with the club-shaped style attached under the margin.

The type is the first species cited below.

1. **Rubacer odoratum** (L.); *Rubus odoratus* L. Sp. Pl. 494. 1753.
2. **Rubacer parviflorum** (Nutt.); *Rubus parviflorus* Nutt. Genera 1: 308. 1818; *Rubus Nutkanus* Moc.; Seringe, DC. Prodr. 2: 566. 1825.
3. **Rubacer tomentosum**; *Rubus velutinus* Hook. & Arn. Bot. Beechey Voy. 140. 1841; Not Vest. 1823.
4. **Rubacer Columbianum** (Millsp.); *Rubus odoratus* var. *Columbianus* Millsp. Bull. W. Va. Agr. Exp. Sta. 2: 355. 1892.

Oreobatus gen. nov.

Prostrate or reclining shrubby vines with light colored, shreddy bark. Leaves petioled, simple, maple- or gooseberry-like, digitately ribbed and lobed with rounded serrate lobes. Flowers showy, usually solitary: sepals ovate or ovate-lanceolate, acuminate or the tips foliaceous, in fruit erect: petals white, 1.5–3 cm. long, broadly obovate: stamens very numerous, hiding the fewer pistils: receptacle flat or nearly so: styles club-shaped, curved; stigma somewhat 2-lobed; young fruit apparently very pubescent, owing to the hairy styles: drupelets not very fleshy, without hairy cushions.

The first of the following two species is regarded as the type:

1. **O. deliciosus** (James); *Rubus deliciosus* James; Torr. Ann. Lyc. N. Y. **2**: 196. 1828.
2. **O. Neo-Mexicanus** (A. Gray); *Rubus Neo-Mexicanus* A. Gray, Pl. Wright. **2**: 55. 1853.

III. A similar inconsistency we find in the Loasaceae, where the genus *Mentzelia* as it is represented in United States is composed of at least four distinct groups deserving generic rank * with just as good right as several other recognized genera in the family.

The principal distinguishing characters are:

Placentae with horizontal lamellae between the seeds; these in 2 rows.
  Filaments 3-cleft at the apex, the middle tooth bearing the anthers, the lateral teeth cuspidate; seeds angled or with folds, not winged; annuals. *Bicuspidaria.*
  Filaments not cleft; seeds very flat, more or less winged; perennials. *Touterea.*
Placentae without lamellae; seeds usually prismatic.
  Placentae slender, filiform; ovules in one row, 10–40; seeds minutely muricate, not striate; filaments free or nearly so. *Acrolasia.*
  Placentae broad, band-like; ovules in 1–2 rows, few; seeds distinctly striate, often rugose; filaments at the base united with the petals into a ring. *Mentzelia.*

Bicuspidaria (S. Wats.) gen. nov.

Mentzelia § *Bicuspidaria* S. Wats. Proc. Am. Acad. **20**: 367. 1885.

Annuals with rather large flowers. Petals 5, free; stamens 80–130, dilated, 3-cleft at the apex, the middle tooth bearing the anthers; placentae with a vertical wing and horizontal lamellae between the ovules and seeds; these 15–40 in 2 rows on each placenta; capsule cylindric, inflated, sessile, thin-walled; seeds irregular, angled or with folds, not winged.

The first of the following species is taken as the type.

1. **B. tricuspis** (A. Gray); *Mentzelia tricuspis* A. Gray, Am. Nat. **9**: 271. 1875.
2. **B. involucrata** (S. Wats.); *Mentzelia involucrata* S. Wats. Proc. Am. Acad. **20**: 367. 1885.
3. **B. hirsutissima** (S. Wats.); *Mentzelia hirsutissima* S. Wats. Proc. Am. Acad. **12**: 252. 1877.

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* It may be that the other three sections of Urban and Gilg, viz., *Micromentzelia*, *Octopetaleia* and *Dendromentzelia* should also be treated as genera; but better knowledge is needed.

TOUTEREA Eaton & Wright, N. Am. Bot. 454. 1840

Bartonia Sims, Bot. Mag. *pl. 1487.* 1804. Not Muhl. 1801.

Torreya Eat. Man. Ed. 7. 560. 1836. Not Raf. 1818.

Hesperaster Cockerell, Torreya, **1**: 142. 1901.

This genus contains nearly all the large-flowered species included in *Mentzelia.* The outer filaments are more or less dilated; in most they are without anthers and in some as large as and resembling the petals. These species are often described as having ten petals. The genus *Touterea* was based on the first two species mentioned below; *Bartonia* Sims on *Bartonia decapetala* and the type of *Hesperaster* is the same. As far as I know, the following species belong here:

1. **T. decapetala** (Pursh); *Bartonia decapetala* Pursh, Bot. Mag. *pl. 1487.* 1812; *B. ornata* Pursh, Fl. Am. Sept. 327. 1814; *Touterea ornata* Eat. & Wright, N. Am. Bot. 454. 1840; *M. ornata* Torr. & Gray, Fl. N. Am. **1**: 534. 1840.
2. **T.** NUDA (Pursh) Eat. & Wright, N. Am. Bot. 454. 1840; *Bartonia nuda* Pursh, Fl. Am. Sept. 328. 1814; *M. nuda* Torr. & Gray, l. c.
3. **T. laevicaulis** (Dougl.); *Bartonia laevicaulis* Dougl.; Hook. Fl. Bor. Am. **1**: 221. 1833; *M. laevicaulis* Torr. & Gray, Fl. N. Am. **1**: 535. 1840.
4. **T. Brandegei** (S. Wats.); *M. Brandegei* S. Wats. Proc. Am. Acad. **20**: 367. 1885.
5. **T. parviflora** (Dougl.); *B. parviflora* Dougl.; Hook. Fl. Bor. Am. **1**: 221. 1833.
6. **T. pterosperma** (Eastw.); *M. pterosperma* Eastw. Proc. Cal. Acad. II. **6**: 290. 1896.
7. **T. stricta** Osterhout Mss.; *Hesperaster strictus* Osterhout, Bull. Torrey Club, **29**: 174. 1902.
8. **T. Rusbyi** (Wooton); *Mentzelia Rusbyi* Wooton, Bull. Torrey Club, **25**: 261. 1898.
9. **T. Wrightii** (A. Gray); *M. Wrightii* A. Gray, Pl. Fendl. 48. 1848.
10. **T. speciosa** Osterhout Mss.; *M. speciosa* Osterh. Bull. Torrey Club, **28**: 689. 1901; *M. aurea* Osterh. Bull. Torrey Club, **28**: 644. 1901. Not Nutt. 1818.

11. **T. densa** (Greene); *M. densa* Greene, Pittonia, **3**: 99. 1896.
12. **T. pumila** (Nutt.); *M. pumila* Nutt.; Torr. & Gray, Fl. N. Am. **1**: 535. 1840.
13. **T. chrysantha** (Engelm.); *M. chrysantha* Engelm.; Brand. Bull. U. S. Geol. Surv. Terr. **2**: 237. 1876; *M. lutea* Greene, Pittonia, **3**: 99. 1896.
14. **T. humilis** (A. Gray); *M. multiflora* var. *humilis* A. Gray, Pl. Wright. **1**: 74. 1852.
15. **T. multiflora** (Nutt.); *Bartonia multiflora* Nutt. Jour. Acad. Phila. II. **1**: 180. 1847.
16. **T. perennis** (Wooton); *M. perennis* Wooton, Bull. Torrey Club, **25**: 260. 1898.
17. T. MULTICAULIS Osterhout, Bull. Torrey Club, **30**: 236. 1903.

ACROLASIA Presl. Rel. Haenk. 2: 39. 1831

Trachyphytum Nutt.; Torr. & Gray, Fl. N. Am. **1**: 533. 1840.

This genus was established on a Chilian species, *A. bartonioides* Presl, which has fewer ovules (12) and fewer stamens than its North American allies, but the structure of the ovary and seeds is the same. All the species are annuals and characterized by the long cylindric capsules, the filiform placentae and the muricate more or less prismatic seeds. Most of the species are small-flowered, with linear, lanceolate or ovate-oblong, laciniate, dentate or more rarely entire sessile leaves. The following North American species belong here:

1. **A. congesta** (Nutt.); *M. congesta* Nutt.; Torr. & Gray, Fl. N. Am. **1**: 534. 1840; *Trachyphytum congestum* Nutt.; Torr. & Gray, l. c.
2. **A. ctenophora**; *M. ctenophora* Rydb. Bull. Torrey Club, **28**: 33. 1901.
3. **A. Tweedyi**; *M. Tweedyi* Rydb. Mem. N. Y. Bot. Gard. **1**: 271. 1900.
4. **A. albicaulis** (Dougl.); *M. albicaulis* Dougl.; Hook. Fl. Bor. Am. **1**: 222. 1833; *Bartonia albicaulis* Hook. l. c.
5. **A. tenerrima**; *M. tenerrima* Rydb. Mem. N. Y. Bot. Gard. **1**: 271. 1900.

6. **A. integrifolia** (Wats.); *M. albicaulis* var. *integrifolia* S. Wats. King's Exp. **5**: 114. 1871; *M. dispersa* S. Wats. Proc. Am. Acad. **11**: 115. 1876.
7. **A. compacta** (A. Nelson); *M. compacta* A. Nels. Bull. Torrey Club, **25**: 275. 1898.
8. **A. gracilenta** (Torr. & Gray); *M. gracilenta* Torr. & Gray, Fl. N. Am. **1**: 534. 1840.
9. **A. affinis** (Greene); *M. affinis* Greene, Pittonia, **2**: 103. 1890.
10. **A. aurea** (Lindl.); *Bartonia aurea* Lindl. Bot. Reg. **22**: *pl. 1831*. 1836. Not *Mentzelia aurea* Nutt. 1818; *M. Lindleyi* Torr. & Gray, Fl. N. Am. **1**: 533. 1840.
11. **A. nitens** (Greene); *M. nitens* Greene, Fl. Francisc. 234. 1891.
12. **A. Veatchiana** (Kellogg); *M. Veatchiana* Kellogg, Proc. Cal. Acad. **2**: 99. 1863.
13. **A. pectinata** (Kellogg); *M. pectinata* Kellogg, Proc. Cal. Acad. **3**: 40. 1868.
14. **A. micrantha** (Torr. & Gray); *M. micrantha* Torr. & Gray, Fl. N. Am. **1**: 535. 1840.

IV. A fourth segregation is proposed in *Synthyris*. Professor Greene has included this genus in *Wulfenia* and he has been followed by many American botanists. *Wulfenia*, represented by European and Asiatic plants, has a 4-valved capsule, which is neither flattened nor emarginate at the apex, and a corolla with a long tube. All the American species have flattened capsules, which are 2-valved and obcordate at the apex. In this respect they agree perfectly with *Veronica*. The original *Synthyris* (*S. reniformis*) and a few related species have a corolla that is built exactly on the same plan as that of *Veronica*, and it is only the general habit that keeps them out of that genus. *S. alpina* and its relatives, on the contrary, have an altogether different corolla, cleft to near the base into two distinct lips. *S. rubra* and its allies have no corollas but agree otherwise both in general appearance and structure of the flower and fruit with *S. alpina*. It would however hardly be advisable to place them in different genera merely on account of the presence or absence of the corolla. The related genera are distinguished as follows:

- Corolla scarcely 2-lipped; almost equally deeply 4-lobed.
  - Corolla tubular-funnelform; capsule neither flattened nor obcordate at the apex, 4-valved.
    - Leaves alternate but mostly basal. *Wulfenia.*
    - Leaves opposite; stem leafy. *Leptandra.*
  - Corolla rotate or short-campanulate; capsule flattened, obcordate, 2-valved.
    - Leaves opposite or whorled; stem leafy. *Veronica.*
    - Leaves alternate, but mostly basal; plant with a mostly naked scape. *Synthyris.*
- Corolla, if present, deeply 2-lipped; upper lip entire, broad, arcuate; lower lip straight and deeply laciniate; leaves alternate but mostly basal; scape bracted. *Besseya.*

SYNTHYRIS Benth.; DC. Prodr. **10**: 454. 1846

This genus was based on *S. reniformis*. *S. rubra* was also included in the genus by the author, but he admits that it is a rather anomalous member, lacking the corolla. It is, however, more nearly related to *S. alpina*, which has a corolla of a different structure. The species belonging here are the following: *S. reniformis* (Dougl.) Benth., *S. major* (Hook.) Heller, *S. pinnatifida* S. Wats. and *S. laciniata* (Gray) Rydb. Whether *S. rotundifolia* A. Gray should also be included or should be made the type of a separate genus is a little doubtful. At present I am inclined to regard it as a *Synthyris*. So also *S. schizantha* Piper, with lacerate corolla-lobes, which species is still more aberrant.

Besseya gen. nov.

Low perennials with a thick rootstock. Basal leaves petioled; blades ovate or oblong, crenate; stem-leaves bract-like, alternate: inflorescence a bracted spike: calyx almost regularly 4-cleft to near the base or cleft to the base on the upper side and then 2–3-lobed: corolla 2-lipped, cleft to near the base, or lacking; upper lip, if present, entire, obovate or cuneate-obovate, concave; lower lip much shorter, often irregularly 2–3-cleft or laciniate: stamens 2, attached at the base of the corolla, or if this is absent on a small disk: capsule flattened, obcordate, 2-valved.

It is with pleasure that I dedicate this genus of western mountain plants to Professor Charles E. Bessey, of the University of Nebraska, my former teacher and the most prominent botanist of the region where these small plants grow.

The first species cited below is regarded as the type.

a. With corolla:

1. **B. alpina** (A. Gray); *Synthyris alpina* A. Gray, Am. Jour. Sci. II. **34**: 251. 1862.
2. **B. Bullii** (Eaton); *Gymnandra Bullii* Eat.; Eat. & Wr. N. Am. Bot. 259. 1840; *Synthyris Houghtoniana* Benth.; DC. Prodr. **10**: 454. 1846.
3. **B. plantaginea** (Benth.); *S. plantaginea* Benth.; DC. Prodr. **10**: 455. 1846.
4. **B. reflexa** (Eastw.); *S. reflexa* Eastw. Proc. Cal. Acad. III. **1**: 124. 1898.
5. **B. Ritteriana** (Eastw.); *S. Ritteriana* Eastw. l. c. 123.

b. Without corolla:

6. **B. rubra** (Dougl.); *Gymnandra rubra* Dougl.; Hook. Fl. Bor. Am. **2**: 103. 1838; *Synthyris rubra* Benth.; DC. Prodr. **10**: 455. 1846.
7. **B. gymnocarpa** (A. Nels.); *Wulfenia gymnocarpa* A. Nelson, Bull. Torrey Club, **25**: 282. 1898.
8. **B. Wyomingensis** (A. Nels.); *W. Wyomingensis* A. Nelson, l. c. 281.

NEW YORK BOTANICAL GARDEN.

Explanation of Plates

PLATE 13

FIG. 1. *Zygadenus glaberrimus* Michx. a, section of flower; b, sepal; c, petal; d, stamens; e, pistils.

FIG. 2. *Toxicoscordion intermedium* Rydb. a, b, etc., as above.

FIG. 3. *Anticlea elegans* (Pursh) Rydb. a, b, etc., as above.

FIG. 4. *Anticlea Sibirica* (L.) Kunth. a, b, etc., as above.

FIG. 5. *Rubus nigrobaccus* Bailey. a, section of receptacle; b, a young drupelet; c, stone.

FIG. 6. *Rubacer odoratum* (L.) Rydb. a, b, c, as in the preceding.

FIG. 7. *Oreobatus deliciosus* (James) Rydb. a, b, c, as in the preceding.

PLATE 14

FIG. 1. *Touterea decapetala* (Pursh) Rydb. a, section of the flower showing two of the petals and two of the similar staminodia; b, one of the petals; c, stamens; d, style; e, partial section of the capsule showing one placenta in front view and half of another in lateral view; f, winged seed.

FIG. 2. *Bicuspidaria tricuspis* (A. Gray) Rydb. a, section of flower; b, fruit; c, pistil; d, stamen with the two cusps; e, section of a part of the capsule, showing in

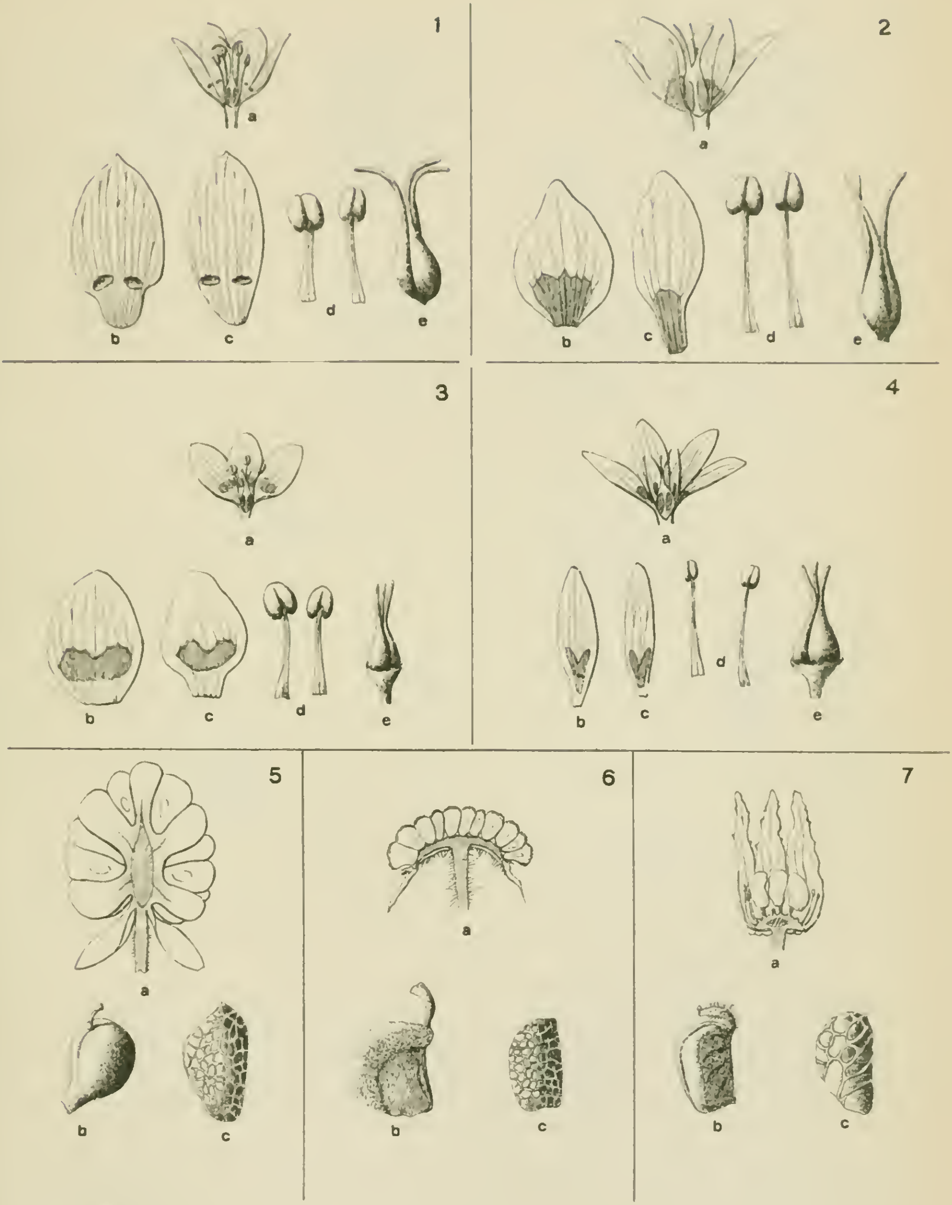
lateral view one half of two placentae with seeds, between them the horizontal lamellae and behind the vertical wings; between the latter are seen seeds on the third placenta; **f**, a seed.

FIG. 3. *Acrolasia albicaulis* (Dougl.) Rydb. **a**, section of flower; **b**, petal; **c**, stamens; **d**, pistil; **e**, capsule; **f**, longitudinal section of the same showing the narrow filiform placenta with seeds removed; **g**, a muricate prismatic seed.

FIG. 4. *Mentzelia oligosperma* Nutt. **a**, section of flower; **b**, stamen; **c**, pistil; **d**, section of a part of the capsule, showing the broad placenta with the seeds removed, except one; **e**, a striate seed.

FIG. 5. *Synthyris reniformis* (Dougl.) Benth. **a**, a flower; **b**, sepal; **c**, corolla laid open; **u**, upper lip; **l**, lower lip; **d**, pistil.

FIG. 6. *Besseya alpina* (A. Gray) Rydb. **a**, **b**, etc., as in the preceding.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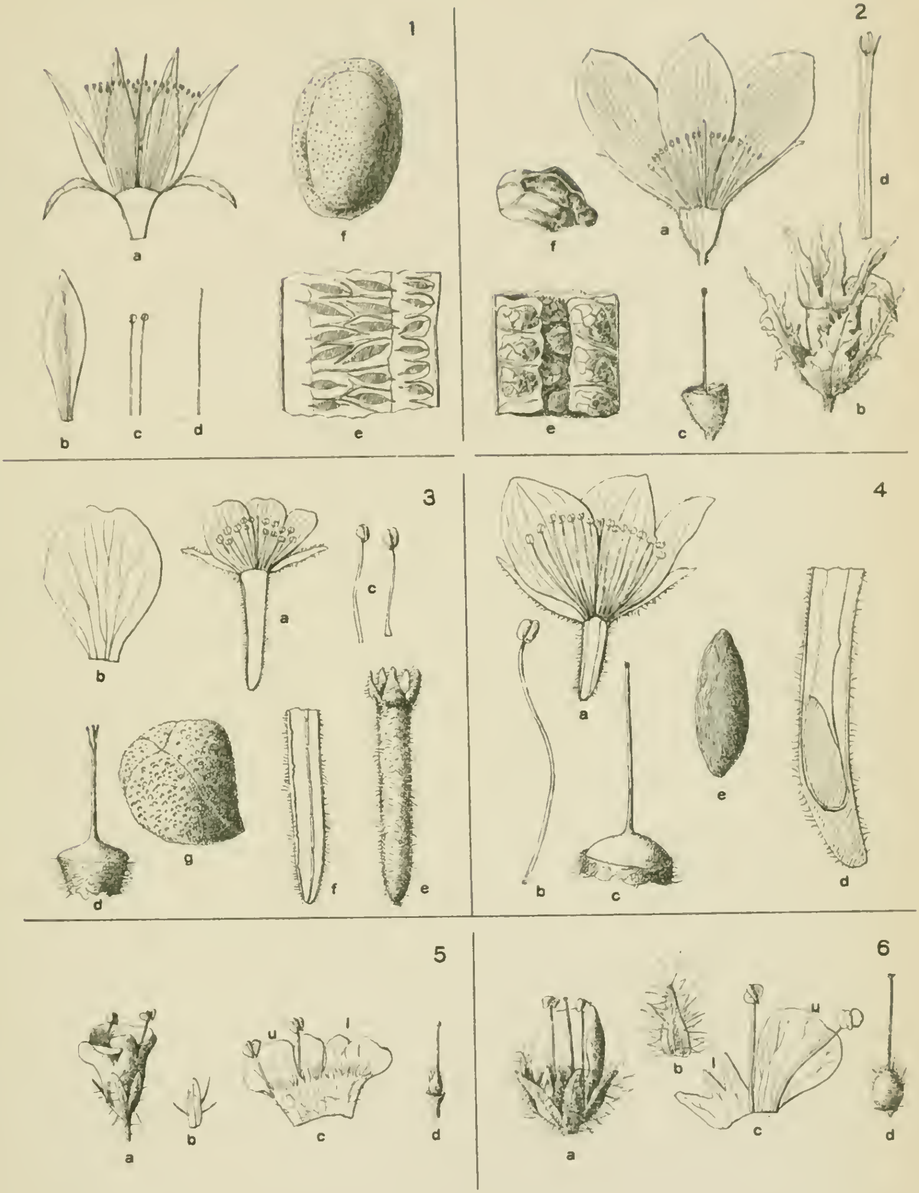
A. Mariotte del.

SEGREGATES OF ZYGADENUS AND RUBUS.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A Mariotte del

SEGREGATES OF MENTZELIA AND SYNTHYRIS.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 38.

THE POLYPORACEAE OF NORTH AMERICA—IV. THE GENUS ELFVINGIA

By WILLIAM ALFONSO MURRILL

NEW YORK
1903

296-301

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 30: ~~271–281.~~ My 1903]

The Polyporaceae of North America.—IV. The Genus Elfvingia

By William Alphonso Murrill

The mycological field of Europe is small as compared with that of America. The European mycologist has in general a small country with limited variation in altitude, geological formation and season, as well as a limited number of host plants, few of which are readily attacked by wood-loving fungi ; hence it is possible to know more minutely the forms that do occur and to segregate varieties according to host, position and other details of which little note has yet been taken in America. The confusion of forms in 'Europe is largely due to former difficulties in travel, limited means, lack of interest in the work of others and lack of generalization, a condition of affairs accounted for to some extent by difference in language and the antipathy common among neighbors. Upon receiving an exotic plant, be it from Guinea or Greenland, the mycologist of limited outlook makes a heroic effort to correlate it with some species growing in his immediate vicinity and, failing to do this, either loses interest altogether in the matter or half-heartedly looks up a name for it in some foreign flora. To send American fungi abroad for determination is usually to be either disappointed or deceived. To many European botanists, Kew is a very foreign country and America is off the map.

One should not be surprised to find, therefore, that many American plants are parading under false names and that many are entirely new to the botanical public ; and what is true of species is likewise true of genera ; the old molds must be recast and several new ones added to accommodate these large additions. For our northern forms, the work of recasting has been largely done by Dr. P. A. Karsten, of Finland, who has to deal with a local flora very similar to our own in its lines of cleavage, although the abundance of species present in our latitude is unknown in Finland. The basis of this similarity between North American and North European and Russian genera is found in the fact that these countries have been practically continuous so far as distribution is concerned, whereas the continents of the southern hemisphere have very probably been for ages widely separated by impassable barriers of open sea. The principles above enunciated are well illustrated in the genus *Elfvingia* of Karsten, a discussion of which follows.

ELFVINGIA Karsten, Findlands Basidsv. 333. 1889

This genus was described by Karsten as follows:

> "Hatten beklädd med en spröd, skorpartad hud, glatt. Cystiderna föga anmärkningsvärda. Basiderna n. klotrunda, 4-sporiga. Sporerna äggrunda, värtfulla, gulbrunaktiga."

The only representative of the genus in Finland, according to Karsten, is *Elfvingia applanata* (Pers.) Karst., a species first described as *Boletus Lipsiensis* by Batsch (Elench. Fung. **2**: 183–185. *pl. 25. Fig. 130. a, b.* 1786), then as *Boletus applanatus* by Persoon (Obs. Myc. **2**: 2. 1799), and later as *Polyporus merismoides* by Corda (Sturm, Deutschl. Flora, **3**: 139–142. *pl. 63.* 1837). Its close relationship to *P. fomentarius* L. may be judged from the fact that Persoon in his Synopsis treats it as a variety of the latter plant, although he had described it as a distinct species only two years before. In the present treatment of the genus *Elfvingia*, **E. Lipsiensis** (Batsch) will not appear, since it does not occur in America, its place being taken by *E. megaloma* (Lév.).

Synopsis of the North American Species

1. Context ferruginous, spores hyaline, pileus usually ungulate. 2.
Context darker, fulvous to chocolate-brown, spores yellowish-brown, pileus usually applanate. 3.

2. Pileus exactly ungulate, pores 3 to a mm., growing in temperate regions south to Carolina. 1. *E. fomentaria.*
Pileus compressed ungulate, pores 5 to a mm., growing in tropical America and the gulf states. 2. *E. fasciata.*

3. Hymenophore annual, persisting above later growths; pileus reniform, margin thin, spores dark brown, roughly echinulate, 8–9 × 7 μ. 3. *E. reniformis.*
Hymenophore truly perennial, tubes stratified, spores smooth or nearly so. 4.

4. Crust white, becoming brown, not separating, spores smooth, 8–9 × 5 μ, growing in temperate regions. 4. *E. megaloma.*
Crust brown, context floccose, softer, spores smooth or slightly echinulate, growing in tropical America. 5.

5. Pileus thick, crust smooth and very hard, hymenium plane, margin truncate, very smooth, often laccate, context very thin, spores smooth or slightly verrucose, 7–9 × 5–6 μ. 5. *E. tornata.*
Pileus thin, crust radially wrinkled, thinner, hymenium concave, margin undulate, never laccate, spores smooth, 8 × 5 μ. 6. *E. Lionetii.*

1. **Elfvingia fomentaria** (L.)

Boletus fomentarius L. Sp. Pl. 1176. 1753.

Boletus ungulatus Bull. Herb. France, *pl. 491. fig. 2, C. D. E.*

Polyporus fomentarius Fr. Syst. **1**: 374. 1821.

Fomes fomentarius Gill. Champ. Fr. **1**: 686. 1878; Icon. 467.

See also Sowerby, Engl. Fungi, *pl. 133*, and Schaeffer, *pl. 137*.

This fungus is widely distributed on birch and beech in the temperate regions of Europe and North America. It varies little in shape and appearance in the north, though very small forms occur in high latitudes. One of these brought from the Isle à la Crosse by Dr. Richardson was described by Berkeley as var. *excavatus* (Ann. Nat. Hist. **3**: 387. 1839). The type specimens at Kew agree in all respects with *P. fomentarius* as it grows in the Adirondack Mountains and in Sweden. A more southern form, larger, thicker, more uniform and ashy in color, is known in Europe as *Polyporus Inzengae* De Not., but as this does not occur in North America it need not be discussed at present. When fruit-bodies of *P. fomentarius* become old and indurated and lose their outer pellicle the horny crust takes a high ivory-black polish and is very different from the usual covering of the plant. It is this form that has frequently been mistaken for *P. nigricans* Fr. At Kew, *P. igniarius* and *P. applanatus* have been variously confused with *P. fomentarius*.

In addition to the usual European and American exsiccati, all of which contain this species, material has been examined from Germany (Magnus), Sweden (Murrill), France (Patouillard), Finland (Karsten), Italy (Bresadola), Scotland (Klotsch), Canada (Macoun), Maine (Ricker), New Hampshire (Miss Minns), Massachusetts (Mrs. French), Wisconsin (Baker), New York (Underwood), Connecticut (Miss White), and most of the other states south to North Carolina and west to California.

2. **Elfvingia fasciata** (Sw.)

Boletus fasciatus Sw. Prod. 149. 1788; Fl. Ind. Occ. **3**: 1921. 1806.

Polyporus fasciatus Fr. Syst. **1**: 373. 1821.

Polyporus sclerodermeus Lév. Ann. Sc. Nat. Bot. III. **5**: 129. 1846.

Polyporus marmoratus Berk. & Curt. Proc. Am. Acad. **4**: 122. 1858.

Fomes fasciatus Cooke, Grevillea, **14**: 21. 1885.

Specimens examined: Ellis & Everhart, N. A. Fungi, no. 1702; Florida (Martin, Calkins, Rolfs, Lloyd, Rau), Louisiana (Langlois), Alabama (Underwood, Earle, Baker), Texas (Egeling), Jamaica (Earle).

This plant is fairly abundant in tropical America, being known from nearly all localities that have been explored. Earle found it at three different points in Jamaica growing on *Cedrela* and cocoanut logs. It replaces *E. fomentaria* in the south, but cannot be confused with it as some have supposed.

3. **Elfvingia reniformis** (Morg.)

Polyporus reniformis Morg. Jour. Cincinnati Soc. Nat. Hist. **8**: 103. 1885.

Fomes reniformis Sacc. Syll. **6**: 187. 1888.

Collections examined: Ohio (Morgan), Kentucky (Miss Price), Indiana (Underwood), Virginia (Murrill, Mrs. Murrill), North Carolina (Memminger), Alabama (Underwood, Earle), Louisiana (Langlois).

When first sent to Kew this plant was determined as *P. applanatus* Pers., a closely allied European species. Later it was placed by Cooke under *P. incrassatus* Berk., a plant indigenous to Australia! It may be said, however, that the specimens now at Kew are not fairly representative even of the form and much less of the habit of Morgan's species. The following extract from one of D. L. James' letters written in 1882 refers to the peculiarities of *P. reniformis*: "I am rather surprised at my fungus turning out to be *P. applanatus*. It grows at the foot of old oak stumps and trees and seems to be an annual, the previous year's growth being found distinct and above the new growth in a decayed condition. The pileus does not harden as in *P. applanatus*." By *P. applanatus* is, of course, meant our ordinary species, *P. megaloma* Lév. "Again, the hymenial surface instead of being flat, is curved upwards in every case, this feature being well shown in the specimen sent.

However, your experience I shall certainly hold above my ignorance."

During a recent trip through the southwestern part of Virginia, I found this fungus very common on stumps and decaying trunks of oak. In every case the fruit-bodies of previous years were dead, with the later growths below. I have specimens taken from a white oak trunk on which I saw the first fruit-bodies two years ago and some of these have three layers, some two and some one, only the last year's growth in each case being alive. This corroborates James' testimony to his belief that the fruit-bodies are annual. During the same trip, I collected a few specimens of *E. megaloma* on its usual hosts and noted with interest that the two species are as distinct in Virginia as they are farther north. Facts thus far collected indicate that *E. reniformis* is a southern form and confined to a much more restricted area than *E. megaloma*, while within this area it is often abundant and quite destructive to the oak, its favorite host.

4. **Elfvingia megaloma** (Lév.)

Polyporus megaloma Lév. Ann. Sc. Nat. Bot. III. **5**: 128. 1846.

Polyporus leucophaeus Mont. Syll. Crypt. 157. 1856.

Fomes megaloma Cooke, Grevillea, **14**: 18. 1885.

Ganoderma leucophaeum Pat. Bull. Soc. Myc. **5**: 73. 1889.

Specimens have been examined from New York (Shear, Murrill), Canada (Anderson), Pennsylvania (Ellis), Virginia (Miss V. W. Murrill, Murrill), and nearly all the other states west to California and south to Georgia. The plant occurs abundantly on dead or dying wood of oak, sweet gum, poplar and other deciduous trees. In the popular mind it is associated with etching because its hymenium changes to a darker color when bruised. Owing to the close resemblance to *P. applanatus* Pers. in habit and appearance, it has been generally known under that name among American mycologists. The correct name for it, however, appears to be that assigned to it by Léveillé in 1846 on receiving specimens collected by Ménand in New York. In connection with his description, he notes that it is near *P. applanatus* in form, consistency and volume, but differs essentially in the color of the cap and the pores and especially in the presence of a wide sterile border circumscribing the tubes below.

5. **Elfvingia tornata** (Pers.)

Polyporus tornatus Pers.; Gaud. Voy. Freyc. Bot. 173. 1826.
Polyporus australis Fr. Elench. 108. 1828.
Fomes australis Cooke, Grevillea, **14**: 18. 1885.
Ganoderma australe Pat. Bull. Soc. Myc. **5**: 71. 1889.
Scindalma tornatum Kuntze, Rev. Gen. **3**: 517. 1898.

Described from islands in the Pacific ocean and apparently of general occurrence throughout tropical America, since most of the collections from that region contain specimens of it. A large plant was collected last year by Percy Wilson in Porto Rico, and Earle on his recent visit to Jamaica found it at three different stations; at Port Maria on a dead limb of a leguminous tree, at Hope Gardens on a dead deciduous trunk and at Port Antonio on the stump of a hog plum and the fallen trunk of a cocoanut palm.

6. **Elfvingia Lionetii** (Rolland)

Ganoderma Lionetii Rolland, Bull. Soc. Myc. **17**: 180. *pl. 8.* 1901.

This plant was collected by M. Lionnet on trunks in the isthmus of Panama. It is closely allied to *E. tornata*, but is thinner with a thinner crust, which is usually profoundly wrinkled from the center outward. The context is floccose, elastic, brownish-rufous, and the spores ovoid, smooth, fulvous, 8 x 5 μ. Several specimens are in the New York Botanical Garden collected by C. L. Smith in Nicaragua.

NEW YORK CITY.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN--No. 39

A PRELIMINARY ENUMERATION OF THE GRASSES OF PORTO RICO

By GEORGE V. NASH

NEW YORK
1903

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, **30**: 369-389. Jl, 1903]

A Preliminary Enumeration of the Grasses of Porto Rico

By George V. Nash

This enumeration is based mainly upon the material in the herbarium of the New York Botanical Garden. The collections of Heller, Underwood and Griggs, Wilson and Goll are there fully represented, and those of Sintenis partially so. A few species, of which we have not seen specimens, have been admitted upon the authority of monographers. Further explorations of the island must add more species, and it is hoped that this enumeration may serve as a help in such further exploration. That this work may be facilitated, it has been deemed advisable to incorporate analytical keys to the tribes, genera and species. This enumeration credits the island with 10 of the 13 grass tribes, 37 genera, and 75 species and varieties, among them 9 hitherto unknown.

Key to the Tribes

A. Spikelets falling from the pedicel entire, naked or enclosed in bristles or a bur-like involucre, or immersed in the internodes of a readily disarticulating rachis, 1-flowered, or if 2-flowered the lower flower staminate (perfect in *Isachne*) : internodes of the rachilla of the spikelet very short, not measurable.

  Spikelets round or somewhat dorsally compressed : hilum punctiform.

    Flowering scale and palet hyaline, thin, much more delicate in structure than the thick-membranous to coriaceous empty scales.

      Spikelets unisexual. Tribe I. MAYDEAE.

      Spikelets in pairs, one sessile, the other pedicellate, the former perfect, the latter sometimes perfect, often with a staminate flower, or frequently empty, abortive or wanting. Tribe II. ANDROPOGONEAE.

    Flowering scale, at least that of the perfect flower, similar in texture to the empty scales, or frequently thicker and firmer, never hyaline and thin.

[The preceding number of the BULLETIN, Vol. 30, No. 6, for June, 1903 (30: 319–368), was issued 11 Je 1903.]

Flowering scale and palet membranous.
  Inflorescence spicate. Tribe III. ZOYSIEAE.
  Inflorescence paniculate. Tribe IV. TRISTEGINEAE.
Flowering scale and palet chartaceous, cartilaginous or coriaceous, very different in appearance from the remaining scales. Tribe V. PANICEAE.
Spikelets much compressed laterally: hilum linear. Tribe VI. ORYZEAE.

B. Spikelets with the empty scales persistent, the rachilla hence articulated above them, 1–many-flowered: internodes of the rachilla of spikelets of 2 or more flowers long and readily measurable.
  Stems herbaceous (except in one species of *Panicum*): leaf-blade sessile, not articulated with the sheath.
    Spikelets borne in open or spike-like panicles or racemes, usually upon distinct and often long pedicels.
      Spikelets 1-flowered. Tribe VII. AGROSTIDEAE.
      Spikelets 2–many-flowered. Tribe IX. FESTUCEAE.
    Spikelets borne in two rows, on short equal pedicels or sessile. Tribe VIII. CHLORIDEAE.
  Stems woody: leaf-blade with a petiole-like base which is articulated with the sheath. Tribe X. BAMBUSEAE.

Tribe I. MAYDEAE

A tall stout grass with the pistillate spikelets enclosed in a globose white bead-like organ. 1. *Coix.*

Tribe II. ANDROPOGONEAE

First scale of the spikelet globose, rugose: racemes not hairy. 2. *Hackelochloa.*
Scales of the spikelet long, flat or convex: racemes hairy.
  Racemes singly disposed.
    Second scale of the sessile spikelet awnless: pedicellate spikelet smaller than the sessile one. 3. *Schizachyrium.*
    Second scale of the sessile spikelet awned: pedicellate spikelet larger than the sessile one. 4. *Diectomis.*
  Racemes in pairs, or sometimes 3's–5's. 5. *Andropogon.*

Tribe III. ZOYSIEAE

A low grass with a narrow spike-like inflorescence. 6. *Anthephora.*

Tribe IV. TRISTEGINEAE

A tall grass with a large panicle of awned spikelets. 7. *Arundinella.*

Tribe V. PANICEAE

1. Spikelets all perfect: leaf-blades sessile.
  a. Spikelets not sunken in the rachis.
    * Spikelets naked, not involucrate.
      Scales 3.
        Lowest scale with a thickened ring-like callus. 8. *Monachne.*
        Lowest scale unappendaged.
          Flowering scale with its opening turned from the rachis. 9. *Paspalum.*

Flowering scale with its opening turned toward the rachis. 10. *Anastrophus.*
Scales 4.
Perfect flowers 2. 11. *Isachne.*
Perfect flower 1.
Second empty scale not saccate at the base.
Empty scales not awned.
Spikelets in very slender 1-sided racemes which are usually whorled or approximate. 12. *Syntherisma.*
Spikelets in panicles or panicled racemes, the latter never whorled, commonly distant.
Spikelets long-hairy, acuminate. 13. *Trichachne.*
Spikelets glabrous or with only short hairs usually orbicular to ovate, if lanceolate glabrous.
Spikelets hemispheric, orbicular or nearly so in outline, the rachis of the 1-sided racemes winged. 14. *Dimorphostachys.*
Spikelets not hemispheric, varying in outline, usually in panicles, rarely in racemes and then the rachis not winged.
Flowering scale without lateral pits or appendages at the base. 15. *Panicum.*
Flowering scale with pits or membranous appendages at the base. 16. *Ichnanthus.*
Empty scales awned or awn-pointed.
Stems creeping : leaf-blades short and broad. 17. *Oplismenus.*
Stems erect : leaf-blades long and narrow. 18. *Echinochloa.*
Second empty scale saccate at the base. 19. *Sacciolepis.*
** Spikelets involucrate.
Involucre of bristles. 20. *Chaetochloa.*
Involucre of 2 spine-bearing valves. 21. *Cenchrus.*
b. Spikelets sunken in one side of the broad flattened rachis. 22. *Stenotaphrum.*
2. Spikelets monoecious : leaf-blades with a petiole-like base. 23. *Olyra.*

Tribe VI. ORYZEAE

Grasses with broad flat leaf-blades and long narrow spikelets. 24. *Pharus.*

Tribe VII. AGROSTIDEAE

Flowering scale with three long awns. 25. *Aristida.*
Flowering scale awnless. 26. *Sporobolus.*

Tribe VIII. CHLORIDEAE

1. Spikelets with 1 perfect flower.
Spikes digitate or in whorls.

8. MONACHNE Beauv. Agrost. 49, *pl. 10.* 1812

Eriochloa H.B.K. Nov. Gen. & Sp. **1** : 94, *pl. 30, 31.* 1815.

Rachis of the inflorescence softly pubescent with short spreading hairs : outer scales of the spikelet pubescent with many long stiff hairs. 1. *M. punctata.*

Rachis merely scabrous on the angles : outer scales less pubescent and with shorter finer hairs. 2. *M. subglabra.*

1. MONACHNE PUNCTATA (L.).

Milium punctatum L. Syst. Ed. 10, 872. 1759.

Eriochloa punctata Hamilt. Prod. 5. 1825.

Humacao, Blauner ; Adjuntas road, near Ponce, Heller 6298.

2. **Monachne subglabra** sp. nov.

A tall somewhat branching grass with rather broad, flat leaf-blades. Stems 8–12 dm. long, glabrous, the nodes densely pubescent with short, spreading hairs : leaves numerous ; sheaths usually shorter than the internodes and much shorter than the blades, ciliate on the margins, the lower ones papillose-hirsute between the nerves ; ligule a ring of short hairs ; blades linear to lanceolate, flat, ascending, or the longer ones drooping, glabrous, very rough on the margins, long-acuminate at the apex, generally narrowed toward the base, 1–3 dm. long and 7–17 mm. wide : inflorescence finally somewhat exserted, the rachis hispidulous on the ridges : racemes ascending, commonly 6–10, the larger 4–6 cm. long, the rachis hispidulous on the margins and more or less setiferous : spikelets on shorter pedicels which usually bear a few long hairs, 3.5 mm. long and about 1.3 mm. wide, elliptic to ovate-lanceolate, acute, a short semicircular first scale usually present, the second and third scales about equal in length, acute, rather sparingly pubescent with appressed hairs, 5-nerved, the third scale bearing in its axil a palet of equal length and a staminate flower, the fourth scale about three fourths as long as the spikelet, elliptic, mucronate, finely transverse-rugose.

Collected at Martin Peña January 31, 1899, by Heller, no. 380.

9. PASPALUM L. Syst. Ed. 10, 855. 1759

1. Racemes scattered along the axis of the inflorescence.
  - *a.* Spikelets broadly elliptic to orbicular, one half as wide as long ; rachis of racemes manifestly wing-margined.
    - * Spikelets not margined.
      - Stems erect or nearly so, stout : leaf-blades long : outer scales of the spikelet with a midnerve.
        - Spikelets glabrous.
          - Third scale of the spikelet white or yellowish at maturity : basal

leaf-sheaths very broad and reticulated, at least when dry.
Spikelets about 1.5 mm. long: racemes numerous. 1. *P. densum.*
Spikelets about 2.5 mm. long: racemes 12–18. 2. *P. Underwoodii.*
Third scale dark brown at maturity: basal sheaths not broad nor reticulated. 3. *P. Boscianum.*
Spikelets pubescent.
Spikelets elliptic, about one half as wide as long, the pubescence appressed. 4. *P. Helleri.*
Spikelets broadly oval or obovate, the pubescence spreading.
Spikelets less than 1.5 mm. long. 5. *P. hemisphaericum.*
Spikelets 2 5–3 mm. long. 6. *P. virgatum.*
Stems slender, creeping at the base: leaf-blades short, rarely more than 5 cm. long: outer scales of the spikelet without a midnerve. 7. *P. orbiculatum.*
** Spikelets surrounded by a broad toothed margin. 8. *P. fimbriatum.*
b. Spikelets narrowly elliptic, less than one half as broad as long: rachis of racemes barely, if at all, margined. 9. *P. Portoricense.*
2. Racemes long and slender, arising in pairs at the apex of the stem, rarely with another one a short distance below. 10. *P. conjugatum.*

1. PASPALUM DENSUM Poir. in Lam. Encycl. **5**: 32. 1804.

A single specimen of this species from Porto Rico has been seen by the writer, and is the type in the herbarium of Lamarck at Paris; it was collected by Ledru.

2. **Paspalum Underwoodii** sp. nov.

A tall perennial with reticulated basal leaf-sheaths, elongated leaf-blades and rather dense inflorescence. Stems 8–12 dm. tall, erect, rather stout at the base: leaves numerous at the base; sheaths glabrous, the basal ones strongly reticulated, at least when dry, rather abruptly narrowed into the blade at or below the middle, equitant; ligule a scarious ring; blades 4–7 dm. long, about 1 cm. wide, long-acuminate at the summit, exceedingly rough on the lower surface, densely hirsute on the upper surface, serrulate on the margins: inflorescence 1.5–2.5 dm. long: racemes 12–18, sessile or nearly so, ascending or nearly erect, the lower ones 7–10 cm. long, the rachis including its serrulate wings about 1 mm. wide and more or less setiferous, usually purplish: spikelets in pairs in two rows, on short hispid pedicels, yellowish green, usually more or less purplish tinged, glabrous, broadly obovate, 2.5 mm. long, 2 mm. broad, and about 0.8 mm. thick, apiculate, the 2 outer scales 3-nerved, apiculate, the third scale yellowish-white, oval, 2.2 mm. long and about 1.7 mm. wide, minutely striate.

Type collected by Underwood and Griggs along roadsides, Mayaguez to Joyua, June 14 to July 22, 1901, no. 149. The following specimens also belong here: Plaza de Humacao, Eggers 676, 1881; between Mayaguez and Añasco, Sintenis 1223, 1885, and near Guanica, 3412*b*, 1885, of the same collector; Santurce, Heller 594; near Mayaguez, Heller 4368.

Related to *P. densum* Poir., but that has more numerous racemes and much smaller spikelets.

3. PASPALUM BOSCIANUM Fluegge, Gram. Mon. 171. 1810.

Paspalum purpurascens Ell. Bot. S. C. & Ga. **1**: 108. 1817.

El Yunque, Luquillo Mts., Wilson 43.

4. **Paspalum Helleri** sp. nov.

A tufted nearly glabrous perennial. Stems 4–8 dm. tall, finally branching above, rather slender, smooth and glabrous, the nodes glabrous: leaves usually 3; sheaths smooth and glabrous, shorter than the internodes; ligule a scarious ring about 1 mm. long; blades erect, or drooping at the end, smooth and glabrous on the surfaces with the exception of some long hairs on the upper surface just back of the ligule, the margins rough, linear, acuminate at the apex, the larger ones 1.5–2.5 dm. long and 5–7 mm. wide: racemes 2–4, sometimes single on the branches, slender, 6–9 cm. long, the rachis more or less flexuous, winged and about 1 mm. wide: spikelets in pairs, 2 mm. long and about 1 mm. wide, elliptic, obtuse, the two outer scales 3-nerved, the first scale pubescent with long weak hairs, the second one glabrous, the third scale and palet greenish.

In fields and waste places. Type collected at Santurce, Jan. 9, 1899, by Heller, no. 10. No. 164, secured by this collector at the same place, also belongs here.

5. PASPALUM HEMISPHAERICUM Poir. in Lam. Encycl. **5**: 31. 1804.

Paspalum paniculatum Gaertn. Fruct. Sem. **2**: 2, *pl. 80.* 1791. In part. Not Linnaeus.

Near Mayaguez, Heller 4399; Adjuntas road, near Ponce, Heller 6227.

6. PASPALUM VIRGATUM L. Syst. Ed. 10, 855. 1759.

In sandy soil, common. Luquillo Mts., Wilson 227; Rio Piedras, Heller 130 and 625; Cataño, Heller 1373; Underwood and Griggs 794.

7. PASPALUM ORBICULATUM Poir. in Lam. Encycl. **5**: 32. 1804.
Paspalum pusillum Vent.; Fluegge, Gram. Mon. 100. 1810.
Wet banks, south of San Juan, Heller 664.

8. PASPALUM FIMBRIATUM H.B.K. Nov. Gen. & Sp. **1**: 93, *pl. 28.* 1815.

In ditch, Coamo to Ponce, Underwood and Griggs 576; Ponce, Heller 6219.

9. **Paspalum Portoricense** sp. nov.

A low tufted nearly glabrous slender perennial. Stems about 1 dm. tall, glabrous, with the exception of a few hairs at the nodes, simple: leaves 2 or 3; sheaths glabrous, usually shorter than the internodes and shorter than the blades; ligule scarious, acute, 1–2 mm. long; blades ascending, flat, rather thin, the upper surface with some long hairs at the very base and a few scattered ones elsewhere, sparingly ciliate on the margins, the lower surface glabrous, linear, acuminate at the apex, usually more or less narrowed toward the base: inflorescence very slender, about 2 cm. long, of 1 or 2 erect branches: spikelets in pairs, one on a long and the other on a short pedicel, elliptic, 1.8 mm. long and 0.7 mm. wide, usually purplish tinged, glabrous, the first and second scales 3-nerved, the third scale greenish-white, a little shorter than the outer scales, obtuse.

Type collected between Aibonito and Cayey, February 8, 1899, by Heller, no. 524.

10. PASPALUM CONJUGATUM Berg. Act. Helv. **7**: 129, *pl. 8.* 1772.
Near Mayaguez, Heller 4397; Mayaguez to Joyua, Underwood and Griggs 175; Luquillo Mts., Wilson 159.

10. ANASTROPHUS Schlecht. Bot. Zeit. 8: 681. 1850.

1. ANASTROPHUS COMPRESSUS (Sw.) Schlecht.; Doell. in Mart. Fl. Bras. **2**^{2}: 102. 1877.
Milium compressum Sw. Prod. 24. 1788.
Rio Blanco, Blauner.

11. ISACHNE R. Br. Prod. 196. 1810

1. **Isachne angustifolium** sp. nov.

A prostrate leafy branching perennial, forming large mats, with narrow leaf-blades and rather small panicles. Stems 1 m. long or less, glabrous or very sparingly pubescent below, the uppermost internode minutely appressed-pubescent: leaves numerous; sheaths glabrous or sparingly hispid, papillose-ciliate on the margins, those on the main stem shorter than the internodes, those on the branches overlapping; ligule a ring of short hairs; blades erect or ascending, linear to linear-lanceolate, acuminate, rough and green on the upper surface, smooth and glaucous on the lower surface, the lower the shorter, only 2–3 cm. long, increasing in length toward the summit where they are 5–10 cm. long and 4–6 mm. wide: panicles long-exserted, 5–8 cm. long, their main axis and widely spreading primary branches minutely pubescent, the secondary branches similarly pubescent and at an angle of about 45° with the primary branches: spikelets about 1.5 mm. long, on shorter pedicels, the two outer scales about equal in length, equalling or a little shorter than the spikelet and sparingly pubescent at the apex, obtuse, the first broadly oval, the second almost orbicular, the two flowering scales glabrous, yellowish, about 1.3 mm. long.

On the summit of El Yunque, Luquillo Mountains, Porto Rico, Wilson, no. 160.

12. SYNTHERISMA Walt. Fl. Car. 76. 1788

Spikelets one quarter as wide as long or more, acute, the fourth scale yellowish when mature. 1. *S. fimbriatum.*

Spikelets one fifth as wide as long, acuminate, the fourth scale greenish when mature. 2. *S. setosum.*

1. SYNTHERISMA FIMBRIATUM (Link) Nash, Bull. Torrey Club, **25**: 302. 1898.

Digitaria fimbriata Link, Hort. Berol. **1**: 226. 1827.

Waste places, common. Cataño, Heller 107, and Bayamon, Heller 422.

2. SYNTHERISMA SETOSUM (Desv.) Nash, Bull. Torrey Club, **25**: 300. 1898.

Digitaria setosa Desv.; Hamilt. Prod. 6. 1825.

Near Mayaguez, Heller 4398.

13. TRICHACHNE Nees, Agrost. Bras. 85. 1829

1. TRICHACHNE INSULARE (L.) Nees, Agrost. Bras. 86. 1829.

Andropogon insularis L. Syst. Ed. 10, 1304. 1759.

Panicum leucophaeum H.B.K. Nov. Gen. & Sp. **1**: 97. 1815.

In fields and along streams, frequent. Heller 136 and 650; Underwood and Griggs 131 and 564; Goll 479; Adjuntas road, near Ponce, Heller 6158.

14. DIMORPHOSTACHYS Fourn. Comptes-Rendus Acad. Par. 80: 441. 1875

1. DIMORPHOSTACHYS PEDUNCULATA (Poir.) Fourn. Mex. Pl. **2**: 15. 1886.

Paspalum pedunculatum Poir. in Lam. Encycl. Suppl. **4**: 315. 1816.

Adjuntas road, near Ponce, Heller 6354.

15. PANICUM L. Sp. Pl. 55. 1753

- 1. Apex of the panicle-branches not extending beyond the insertion of the spikelets.
  - *a*. Stems herbaceous.
    - Spikelets scattered, on long pedicels of varying length.
      - Fourth scale of the spikelet smooth: low grasses, less than 5 dm. tall.
        - Panicle large and effuse, over 1 dm. long: spikelets numerous, less than 1.5 mm. long.
          - Leaf-blades narrowly ovate, rarely exceeding 7 cm. long: spikelets 1 mm. long. 1. *P. brevifolium.*
          - Leaf-blades lanceolate, rarely less than 1 dm. long: spikelets 1.3 mm. long. 2. *P. trichanthum.*
        - Panicle small, less than 1 dm. long: spikelets few, 1.5 mm. long or more.
          - Stems erect, if prostrate in age never rooting at the lower nodes.
            - Spikelets less than 2 mm. long.
              - Leaf-blades with the upper surface hirsute, the larger over 1 cm. wide. 3. *P. comophyllum.*
              - Leaf-blades with the upper surface glabrous or merely puberulent, less than 5 mm. wide. 4. *P. Nashianum.*
            - Spikelets more than 2 mm. long. 5. *P. consanguineum.*
          - Stems erect only toward the end, the base prostrate and rooting at the lower nodes
            - Leaf-blades lanceolate, pubescent, less than 5 mm. wide. 6. *P. parvifolium.*
            - Leaf-blades ovate-lanceolate, more than 5 mm. wide. 7. *P. oplismenoides.*
      - Fourth scale of the spikelet transversely rugose: tall stout grasses. 8. *P. maximum.*
    - Spikelets crowded on short nearly equal pedicels, in short clusters on one side of the panicle-branches.
      - Outer scales of the spikelet with cross-veinlets connecting the longitudinal nerves. 9. *P. paniculatum.*
      - Outer scales without cross-veinlets.
        - Fourth scale of the spikelet transversely rugose.
          - Spikelets about 2 mm. long: stems slender: leaf-blades ovate-lanceolate, usually less than 5 cm. long. 10. *P. prostratum.*

Spikelets about 3 mm. long : stems stout : leaf-blades long and linear. 11. *P. molle.*

Fourth scale of the spikelet smooth. 12. *P. laxum.*

b. Stems woody, bamboo-like. 13. *P. latifolium.*

2. Apex of the panicle-branches extending beyond the insertion of the spikelets in an awn-like appendage.

Second scale of the spikelet 3-nerved, the fourth scale smooth. 14. *P. Sintenisii.*

Second scale of the spikelet 5–7-nerved, the fourth scale transversely rugose. 15. *P. flavescens.*

1. PANICUM BREVIFOLIUM L. Sp. Pl. 59. 1753.

In fields and waste places, frequent. Santurce, Heller 157; Martin Peña, Heller 387; Luquillo Mts., Wilson 283; Adjuntas road, near Ponce, Heller 6094.

2. PANICUM TRICHANTHUM Nees, Agrost. Bras. 210. 1829.

In moist ground, between Aibonito and Cayey, Heller 531.

3. **Panicum comophyllum** sp. nov.

A tufted densely pubescent perennial, finally much-branched, with broad flat leaf-blades and rather large panicles. Stems 3–4 dm. tall, hirsute with long ascending hairs : leaves 5–7; sheaths densely hirsute with spreading hairs, the primary ones shorter than the internodes and the blades; ligule a ring of stiff hairs about 2 mm. long; blades spreading or ascending, flat, softly hirsute on both surfaces with spreading hairs, those on the upper surface the longer, ciliate on the margin with stiffer hairs; those on the main stem oblong-linear to ovate-lanceolate, acute, barely cordate at the somewhat clasping base, 5–7 cm. long, 10–13 mm. wide : panicle somewhat exserted, 5–7 cm. long and about as broad, broadly ovate, the main axis pubescent with short spreading hairs, its branches somewhat ascending : spikelets broadly obovate, 1.5 mm. long and about 1 mm. wide, pubescent with spreading hairs.

Type collected in rich soil at Santurce, January 9, 1899, by Heller, no. 12.

Related to *P. ciliosum* Nash, of the southern United States, but readily distinguished by its softly pubescent leaf-blades.

4. PANICUM NASHIANUM Scribn. Bull. U. S. Dept. Agric. Div. Agrost. 7 : 79. 1897.

In sand, quite common. Vega Baja, Heller, 639; Manati to

Vega Baja, Underwood and Griggs 955; Santurce, Heller 982*b* and 6442.

5. PANICUM CONSANGUINEUM Kunth, Rev. Gram. **1**: 36. 1829.
Sandy soil, Santurce, Heller 982.

6. PANICUM PARVIFOLIUM Lam. Ill. **1**: 173. 1791.
Bayamon, Sintenis 1216.

7. **Panicum oplismenoides** sp. nov.

A smooth and glabrous prostrate leafy perennial with much of the habit of *Oplismenus setarius*, with short broadly lanceolate leaf-blades and spreading panicles. Stems slender, rooting at the lower nodes, branching: leaves numerous; sheaths much shorter than the internodes and about one half as long as their blades; ligule a very narrow scarious ring; blades spreading, shorter than the internodes, broadly lanceolate to ovate-lanceolate, often somewhat undulate on the margins, 2–3 cm. long, 6–10 mm. wide: panicles but little exserted, broadly ovate, 3–4 cm. long, the branches spreading: spikelets elliptic, 1.8–2 mm. long and a little less than 1 mm. broad, the first scale a little more than one half as long as the spikelet, 5-nerved, broadly ovate, obtuse, the second and third about equal in length, 5-nerved, a little exceeding the white flowering scale, the third scale with a manifest palet nearly as long as itself.

Collected on the edge of a ditch at Vega Baja, May 9, 1899, by Heller, no. 1316.

Related in habit and general appearance to *P. polygonoides* Lam., but in that the leaf-blades are smaller and with hispid sheaths and the spikelets globular.

8. PANICUM MAXIMUM Jacq. Ic. Pl. Rar. **1**: 13. 1781–6.
Martin Peña, Heller 377; Martin Peña and Lecheria, Goll 31.

9. **Panicum paniculatum** (L.).
Paspalum paniculatum L. Syst. Ed. 10, 855. 1759.
Panicum fasciculatum Sw. Prod. 22. 1788.

In sandy and rocky soil, frequent. Rio Piedras, Heller 135; Aguadilla, Heller 4528; Sprengel; H. Wydler 311; Adjuntas road, near Ponce, Heller 6226 and 6302.

It may be of interest to note here that the specimen from which Sloane's figure (Hist. Jam. *pl. 72*, *f. 2*) was drawn, and on which Linnaeus based his *Paspalum paniculatum*, has been examined by the writer, and that it is what is commonly known as *Panicum fasciculatum* Sw.

10. PANICUM PROSTRATUM Lam. Ill. **1**: 171. 1791.

Cane field between Ponce and Coamo, Heller 497.

11. PANICUM MOLLE Sw. Prod. 22. 1788.

Along railroad, Bayamon, Heller 100; Yauco, Heller 6293.

12. PANICUM LAXUM Sw. Prod. 23. 1788.

In fields, common. Between Aibonito and Cayey, Heller 522; Santurce, Heller 983; Cataño, Heller 1378.

13. PANICUM LATIFOLIUM L. Sp. Pl. 58. 1753.

In woods and thickets, common. Maricao, Sintenis 215; Mayaguez, Heller 4375; Arecibo, Heller 343; Luquillo Mts., Wilson 350; Coamo, Goll 699; Bayamon, Goll 227.

14. **Panicum Sintenisii** sp. nov.

A tufted glabrous perennial with long narrow flat leaf-blades and a slender panicle. Stem 4–6 dm. tall, slender, producing panicle-bearing branches from the upper sheaths: leaves about 4; sheaths several times shorter than the internodes and the blades; ligule a ring of short hairs; blades narrow and elongated, flat toward the apex, but folded below for a considerable distance, at least when dry, giving the blade a long-stalked appearance, 1–2 dm. long and about 2 mm. wide at the flat portion, the lower folded portion about one quarter this width, long-acuminate: panicle very slender, 4–7 cm. long, its branches appressed, 1–2 cm. long, each running out into a bristle-like termination as do its divisions: spikelets about 2 mm. long, acute, as are also all the scales, the first scale 1-nerved, about one half as long as the spikelet, the second one 3-nerved, about two thirds as long as the spikelet, the third scale 5-nerved and equalling the fourth scale or a little shorter than it, the fourth scale very acute.

In woods, Guanica, Sintenis 3463.

Related to *P. Chapmani* Vasey, but that has stouter spikelets and all the scales with more nerves.

15. PANICUM FLAVESCENS Sw. Prod. 23. 1788.

Near Mayaguez, Heller 4373 and 4488.

16. ICHNANTHUS Beauv. Agrost. 56, *pl. 12, f. 1.* 1812

1. ICHNANTHUS PALLENS (Sw.) Munro; Benth. Fl. Hongk. 414. 1861.

Panicum pallens Sw. Prod. 23. 1788.

In wet shaded places, common. Bayamon, Heller 92; Santurce, Heller 826; Mayaguez, Heller 4374 and 4479; Puente Fluco, Goll 884; Adjuntas road, near Ponce, Heller 6093.

17. OPLISMENUS Beauv. Fl. Owar. **2**: 14, *pl. 68.* 1807

1. OPLISMENUS SETARIUS (Lam.) R. & S. Syst. **2**: 481. 1817.

Panicum setarium Lam. Ill. **1**: 170. 1791.

In moist soil, frequent. Piñon, Goll 623; Adjuntas road, near Ponce, Heller 6303.

18. ECHINOCHLOA Beauv. Agrost. 53, *pl. 11, f. 11.* 1812.

1. ECHINOCHLOA COLONA (L.) Link, Hort. Berol. **2**: 209. 1833.

Panicum colonum L. Syst. Ed. 10, 870. 1759.

In fields and waste places, common. Cataño, Heller 108; Mayaguez, Heller 4409; Coamo Springs, Goll 660.

19. SACCIOLEPIS Nash, in Britt. Man. 89. 1901.

1. **Sacciolepis striata** (L.).

Holcus striatus L. Sp. Pl. 1048. 1753.
Panicum striatum Lam. Ill. **1**: 172. 1791.
Panicum gibbum Ell. Bot. S. C. & Ga. **1**: 116. 1817.
Sacciolepis gibba (Ell.) Nash, in Britt. Man. 89. 1901.

Wet ground, near Santurce, Heller 1363.

20. CHAETOCHLOA Scribn. Bull. U. S. Dept. Agric. Div. Agrost. 4: 38. 1897

Setae at the base of the spikelet 5 or more, involucrate, antrorsely scabrous.
  Setae short, not more than twice as long as the spikelet: inflorescence usually slender. 1. *C. purpurascens.*
  Setae longer; inflorescence stout. 2. *C. imberbis.*
Setae 1–3 at the base of each spikelet, not involucrate, retrorsely scabrous above, antrorsely below. 3. *C. scandens.*

1. CHAETOCHLOA PURPURASCENS (H.B.K.) S. & M. Bull. U. S. Dept. Agric. Div. Agrost. 21: 13. 1900.

Setaria purpurascens H.B.K. Nov. Gen. & Sp. **1**: 110. 1815.

In fields and waste places, frequent. Santurce, Heller 14 and 329.

2. CHAETOCHLOA IMBERBIS (Poir.) Scribn. Bull. U. S. Dept. Agric. Div. Agrost. 4: 39. 1897.

Panicum imberbe Poir. in Lam. Encycl. Suppl. **4**: 272. 1816.

Sintenis 208 (*fide* Scribn. & Merr. l. c.); Adjuntas road, near Ponce, Heller 6240.

CHAETOCHLOA IMBERBIS GENICULATA (Lam.) S. & M. Bull. U. S. Dept. Agric. Div. Agrost. 21: 12. 1900.

Panicum geniculatum Lam. Encycl. **4**: 727. 1797.

Differs from the species in having stouter geniculate stems, broader leaf-blades, and a longer inflorescence.

Humacao, Blauner 233.

3. CHAETOCHLOA SCANDENS (Schrad.) S. & M. Bull. U. S. Dept. Agric. Div. Agrost. 21: 17. 1900.

Setaria scandens Schrad., Schult. Mant. **2**: 279. 1824.

Sintenis 6498 (*fide* Scribn. & Merr. l. c.).

21. CENCHRUS L. Sp. Pl. 1049. 1753.

Involucres 4-6-flowered, armed at the base with erect barbed bristles. 1. *C. echinatus.*

Involucres 2-flowered, armed at the base with generally shorter reflexed spines. 2. *C. tribuloides.*

1. CENCHRUS ECHINATUS L. Sp. Pl. 1050. 1753.

In sandy waste places, common. Santurce, Heller 3 and 1346; Cayey, Underwood and Griggs 406.

2. CENCHRUS TRIBULOIDES L. Sp. Pl. 1050. 1753.

Fajardo, Blauner 242.

22. STENOTAPHRUM Trin. Fund. Agrost. 175. 1820

1. STENOTAPHRUM SECUNDATUM (Walt.) Kuntze, Rev. Gen. 794. 1891.

Ischaemum secundatum Walt. Fl. Car. 249. 1788.

Roadside near Bayamon, Heller 1241; in sand, Manati to Vega Baja, Underwood and Griggs 959.

23. OLYRA L. Syst. Ed. 10, 1261. 1759

1. OLYRA LATIFOLIA L. Syst. Ed. 10, 1261. 1759.
Near Mayaguez, Heller 4443 and 4583.

24. PHARUS P. Br. Hist. Jam. 344. 1756

1. PHARUS BRASILIENSIS Raddi, Agrost. Bras. 21. 1823.

Rio Blanco, Blauner; ravine, Coamo Springs, Underwood and Griggs 505 and 845.

25. ARISTIDA L. Sp. Pl. 82. 1753

1. ARISTIDA DISPERSA Trin. & Rupr. Mem. Acad. Sci. St. Petersb. VI. **7**: 129. 1829.
Guanica, Sintenis 3766.

26. SPOROBOLUS R. Br. Prod. 169. 1810

Stems tufted, not arising from rootstocks.
  Spikelets about 2 mm. long, the second scale half as long or less. 1. *S. Indicus.*
  Spikelets about 3 mm. long, the second scale fully as long. 2. *S. purpurascens.*
Stems arising from long branching rootstocks. 3. *S. Virginicus.*

1. SPOROBOLUS INDICUS (L.) R. Br. Prod. 170. 1810.
Agrostis Indica L. Sp. Pl. 63. 1753.

In sandy soil, common. Santurce, Heller 985 and 1275; Lecheria, Goll 22.

2. SPOROBOLUS PURPURASCENS (Sw.) Hamilt. Prod. 5. 1825.
Agrostis purpurascens Sw. Prod. 25. 1788.
Near Mayaguez, Heller 4590.

3. SPOROBOLUS VIRGINICUS (L.) Kunth, Rev. Gram. **1**: 67. 1829.
Agrostis Virginica L. Sp. Pl. 63. 1753.

On sand dunes and in sandy soil, frequent. Santurce, Heller 1412; Maunabo, Sintenis 5084.

27. CHLORIS Sw. Prod. 25. 1788.

Spikes slender: flowering scale lanceolate, not long-ciliate. 1. *C. radiata.*
Spikes stout: flowering scale oval, long-ciliate on the margins above. 2. *C. Paraguiensis.*

1. CHLORIS RADIATA Sw. Prod. 26. 1788.

In moist soil and waste places, common. Cataño, Heller 109;

Rio Piedras, Heller 195 and 196; Bayamon, Underwood and Griggs 883; Santurce, Heller 6380.

2. CHLORIS PARAGUIENSIS Steud. Syn. Pl. Gram. 204. 1855.

Chloris barbatum Sw. Fl. Ind. Occ. **1**: 200. 1797. Not *Andropogon barbatum* L. Amoen. Acad. **5**: 412. 1759.

Near Mayaguez, Heller 4417.

28. EUSTACHYS Desv. Nouv. Bull. Soc. Philom. 2: 188. 1810

1. EUSTACHYS PETRAEA (Sw.) Desv. Nouv. Bull. Soc. Philom. **2**: 189. 1810.

In sand, Vega Baja, Heller 131; Santurce, Heller 6422.

29. HETEROSTECA Desv. Nouv. Bull. Soc. Philom. 2: 188. 1810

1. **Heterosteca rhadina** sp. nov.

Stems tufted, 2.5–4 dm. long, slender, finally prostrate at the base and branching above: leaves several; sheaths strongly nerved, glabrous, or the lower ones sometimes more or less pubescent; ligule a narrow scarious ring; blades flat, narrowly linear, acuminate, more or less hirsute on both surfaces, especially on the upper, less than 1 dm. long, 1–2 mm. wide: spikes 3–7, short, spreading or reflexed, of 1–3 spikelets, the 3-angled rachis hispidulous on the angles, its internodes long, usually exceeding one half the length of the empty scales: spikelets distant, appressed to the rachis, the purple empty scales very acute, 1-nerved, hispidulous on the stout midrib, the first shorter than the second which is 5–6 mm. long, the first flowering scale 3-nerved, the nerves extending into short awns, the lateral ones barely reaching the apex of the body of the scale, the central one extending about 1 mm. beyond it, enclosing a perfect flower and a palet longer than its body, the second flowering scale likewise 3-nerved, the nerves extending into hispidulous awns longer than the body, enclosing a staminate flower and a longer palet.

Collected on the Adjuntas road, near Ponce, by Heller, no. 6057, and distributed as *Bouteloua Americana* (Sw.) Scribn. The *Aristida Americana* cited in the synonymy of *Bouteloua litigiosa* Lag. by Grisebach (Fl. Brit. W. I. 537) is accredited to Swartz (Obs. Bot. *t. 2*, *f. 2*). Swartz, however, distinctly indicates there the real authorship of the species by quoting the original Linnaean description in the Systema Naturae. Both authors refer the plant to Jamaica, so that the plate and description of Swartz may in all probability be safely taken as characterizing the Linnaean plant also. The genus *Heterosteca* was founded by Desvaux on one species, *H. juncifolia*. At a later date he probably became acquainted with the *Aristida Americana* Sw., for in a subsequent publication (Jour. de Bot. **3**: 68. 1813) he changes the name to *Heterosteca Americana*, citing *H. juncifolia* as a synonym.

The plant of Swartz is quite different from the one we have under consideration, differing in the more numerous spikes with more spikelets, and in the second flowering scale being reduced to a 3-awned empty rudiment.

30. ELEUSINE Gaertn. Fruct. **1**: 7. 1788

1. ELEUSINE INDICA (L.) Gaertn. Fruct. **1**: 8. 1788.

Cynosurus Indicus L. Sp. Pl. 72. 1753.

In cultivated and waste ground, common. Cataño, Heller 110; between Ponce and Coamo, Heller 499; Mayaguez, Heller 4410; Lecheria, Goll 20.

31. DACTYLOCTENIUM Willd. Enum. 1029. 1809

1. DACTYLOCTENIUM AEGYPTIUM (L.) Willd. Enum. 1029. 1809.

Cynosurus Aegyptius L. Sp. Pl. 72. 1753.

In cultivated and waste grounds, common. Santurce, Heller 155; Mayaguez, Heller 4411; Guanica, Sintenis 3469; Guayama, Goll, 513; Coamo Springs, Goll 661; Bayamon, Underwood and Griggs 900.

32. LEPTOCHLOA Beauv. Agrost. 71, *pl. 15, f. 1.* 1812

1. LEPTOCHLOA VIRGATA Beauv. Agrost. 166. 1812.

Moist ground near Añasco, Heller 4535.

33. GYNERIUM H. & B. Pl. Aequin. **2**: 112, *pl. 115.* 1809

1. GYNERIUM SACCHAROIDES H. & B. Pl. Aequin. **2**: 112, *pl. 115.* 1809.

Along streams, Yauco, Underwood and Griggs 718.

34. PHRAGMITES Trin. Fund. Agrost. 134. 1820

1. Phragmites occidentalis (Sieb.) Trin.; Steud. Nomen. Ed. 2, **2**: 324. 1841.

Arundo occidentalis Sieb.; Schult. Mant. **2**: 289. 1824.

Near Guanica, Heller 6289. This specimen is doubtfully referred here, its immaturity preventing a more definite determination. It was distributed as *Arundo Donax;* it hardly appears to be that plant, however. It may only be a form of the world-wide *P. Phragmites.* Mature flowering specimens of this are greatly desired.

35. ERAGROSTIS Beauv. Agrost. 70, *pl. 14, f. 11.* 1812

Flowers perfect: stems not rooting at the lower nodes.
Palet long-ciliate on the margins: panicle narrow and spike-like. 1. *E. ciliaris.*
Palet not long-ciliate: panicle loose and open.
Annual: leaf-blades less than 1 dm. long. 2. *E. Purshii.*
Perennial: leaf-blades more than 1 dm. long. 3. *E. Elliottii.*
Flowers dioecious: stems creeping. 4. *E. hypnoides.*

1. Eragrostis ciliaris (L.) Link, Hort. Berol. **1**: 192. 1827.

Poa ciliaris L. Syst. Ed. 10, 875. 1759.

In waste and cultivated soil, common. Bayamon, Heller 101; Santurce, Heller 156 and 6404; Cabo Rojo, Sintenis 838; Bayamon, Underwood and Griggs 895; Ponce, Heller 6218.

2. Eragrostis Purshii Schrad; Shlecht. Linnaea, **12**: 451. 1838.

Rio Piedras, Heller 197; between Aibonito and Cayey, Heller 551; Montellano, Goll 473; Adjuntas road, near Ponce, Heller 6198. These specimens are doubtfully referred here.

3. Eragrostis Elliottii S. Wats. Proc. Am. Acad. **25**: 140. 1890.

Poa nitida Ell. Bot. S. C. & Ga. **1**: 162. 1817. Not Lam. 1791.

Eragrostis nitida Chapm. Fl. S. U. S. 564. 1860.

Moist sandy soil, Santurce, Heller 584.

4. Eragrostis hypnoides (Lam.) B.S.P. Prel. Cat. N. Y. 69. 1888.

Poa hypnoides Lam. Ill. 185. 1791.

Roadsides, Rio Piedras, Heller, 649; Bayamon, Sintenis 1225.

36. UNIOLA L. Sp. Pl. 71. 1753

1. UNIOLA RACEMIFLORA Trin. Bull. Sc. Acad. St. Petersb. **1**: 68. 1836.

Near Salinas de Cabo Rojo, Sintenis 839.

37. ARTHROSTYLIDIUM Rupr. Mem. Acad. St. Petersb. VI. **5**: 117. 1839

Leaf blades very narrowly linear or hair-like.	1. *A. capillifolium.*
Leaf-blades lanceolate.	2. *A. multispicatum.*

1. ARTHROSTYLIDIUM CAPILLIFOLIUM Griseb. Mem. Am. Acad. II. **8**: 531. 1863.

Near Sabanagrande, climbing on tall trees, Sintenis 3891.

2. ARTHROSTYLIDIUM MULTISPICATUM Pilger in Urban, Symb. Ant. **2**: 341. 1901.

In woods near Maricao and Adjuntas, Sintenis 209 and 4016 (according to Pilger).

A number of other specimens of the Bambuseae are in collections, but they are without inflorescence and so undeterminable

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN--No. 40

THE PHYLLODES OF OXYPOLIS FILIFORMIS, A SWAMP XEROPHYTE

By ROSINA J. RENNERT

NEW YORK
1903

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 30: 403-411. Jl, 1903]

The Phyllodes of Oxypolis filiformis, a Swamp Xerophyte*

By Rosina J. Rennert

A large number of species of higher plants which live in ponds, marshes and other extremely moist habitats present structural characters of a xerophytic nature which have been most difficult of interpretation. A special study of the phyllodes of *Oxypolis filiformis* † was undertaken by the author in the hope that some additional light might be thrown on the subject. This work was carried on in the New York Botanical Garden under the direction of Dr. D. T. MacDougal, to whom I am indebted for valuable advice and fruitful suggestions.

Oxypolis filiformis is an umbellifer which grows in swamps and along the borders of ponds in the southeastern United States, as far north as Delaware. The leaves exhibit curious modifications by which they depart widely from the uniformly broad or widely dissected umbelliferous type, being reduced to stiff grayish-green awl-shaped phyllodes, which have a structure as if made up of a number of sections of varying lengths, the joints being distinctly noticeable and marking the position of peculiar septa in the interior tissues. This habit of the leaves gives the plant a rush-like appearance, an effect which is heightened by the small size of the cauline, and the strong development of the basal phyllodes. The entire phyllode is flattened along one side. A minute pit is to be observed externally to every septum, occurring in the middle of the slightly flattened surface.

Briquet ‡ has given a detailed account of the results of his examination of this plant with respect to the anatomy of the phyllodes. He describes the epidermis as a single layer of cells with curved outer walls protected by a thickened outer membrane and a folded cuticle. The stomata were noted as either flush with the surface, or sunken slightly below, being about 48 to 54 μ in length. Directly underneath the epidermis is a hypoderm composed of small sclerotic cells with a small lumen. The hypoderm is one to three layers in thickness, and is interrupted only underneath the stomata. The chlorophyl-bearing tissue consists of three to six layers of cells, the outer ones of which are palisaded. The innermost layers are more loosely arranged. Internal to the chlorophyl-bearing cells is a cylinder of four or five layers of large thin-walled cells, designated as endoderm by Briquet. The fibro-vascular bundles are situated in this tissue. The pericycle comes into contact with the chlorophyl-bearing tissue in places, however. The axial portions of the phyllodes were found to consist of thin-walled stellate elements which are in contact at the tips of the rays. The septa were found to be composed of sclerotic cells with numerous branching canals extending radially through the walls. The fibro-vascular bundles are unbranched in the intervals but break up at the septa and form a mesh of anastomosing branches, which however do not traverse the septa radially to any great distance.

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* Read before the Botanical Society of America, by invitation, at Pittsburg, Pa., July 1, 1902.

† Oxypolis filiformis (Walt.) Britton. *Tiedemannia teretifolia* (Muhl.) DC.

‡ Briquet, J. Etude de la feuille du *Tiedmannia teretifolia* DC. Bull. Herb Boiss. 5 : 461–465. 1897.

Briquet explains the seemingly anomalous possession of transpiration-hindering hypoderm by this marsh plant by the fact that it is subject to two extremes of conditions. The mechanical advantages from the cylindrical form of the phyllodes, and the aërating capacity of the stellate tissue would be of advantage during the early spring season, when the plant is more or less submerged. The shape of the leaf would present a reduced surface and the hypoderm would check transpiration during the mid-summer season after the waters have subsided.

My own examination of this plant and the results of the experimental tests made with it have revealed some structural features not mentioned by Briquet, and lead to a somewhat different interpretation of its adaptative features.

Some plants brought from Georgia and Florida in 1901 and 1902 were grown in the greenhouse under various conditions as described below. The septa in the phyllodes of these specimens were found to consist chiefly of small thin-walled cells containing chlorophyl, and resembling the elements of the other chlorophyl-bearing tissue, with only an occasional thick-walled sclerotic cell. The endoderm was found to be continued on the surfaces of the septa. I am not able to account for the difference in these septa as observed by Briquet and myself, except to suggest that his plants were grown under conditions which induced the sclerosis of the elements of the septa and which he has not described.

The most important additional fact concerning the structure of these organs, however, is that all of the specimens in the herbarium of the New York Botanical Garden, and of those cultivated by myself in the open, exhibit the pits or depressions mentioned above, and this feature is to be seen even in the first leaf of the seedlings. These pits seem to be the external openings of oil or resin glands which are situated immediately below each septum. The pit is partly closed by a chlorophylless outgrowth of the lower margin, which can be distinguished by the unaided eye as a minute scale. Goebel * describes similar outgrowths on the phyllodes of *Crantzia linearis*, an umbellifer of the same habit as *Oxypolis*, and despite the fact that they occur along one side of the leaf only, he holds the opinion that they are vestigial leaf-divisions. This conclusion can hardly be valid with respect to the pits and scales of *Oxypolis*. These formations are absent from the basal septa as they would be if vestigial leaf-divisions, but as a matter of fact the scales and pits originate on a line ninety degrees from the plane of the stipules. Furthermore the specialized structute of the formations in question militates against their acceptance as vestiges.

It was found that the floor of the pit is on a level with the plane of the diaphragm. It is this floor and the flap which closes the orifice only, whose structure indicates a specialization of function. With these exceptions the invagination is lined by a continuation of the normal epidermal cells of the phyllode, covered by a cuticle continuous with that on the outside of the leaf. The floor and flap have an epidermis of smaller cells the outer walls of which are slightly convex, forming small papillae. No cuticle is present. The small openings which occur in this epidermis measure about 19 μ in diameter and are formed by two cells broadly elliptical in shape. Directly below these epidermal cells and making up the greater part of the flap is a mass of irregularly shaped cells dovetailed compactly into each other. The epidermal cells as well as the cells of this tissue contain a great amount of resin or oil. Enlarged tracheae are to be found in great numbers leading into this compact tissue and forming a solid mass below it. The anastomosing bundles of the septa end here. In the light of this peculiar structure, it seems reasonable to regard these pits as glands for the secretion of oil or resin.

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* Goebel, K. Organographie der Pflanzen, 494. 1901.

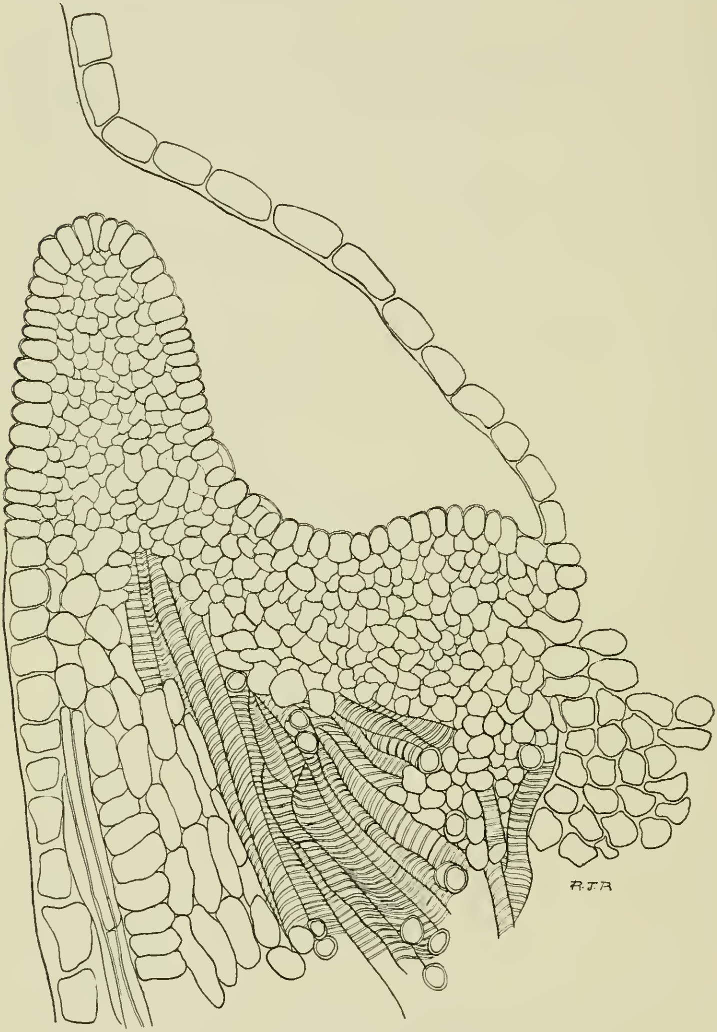

FIG. 1. Oil-gland of phyllode, × 140.

In opposition to Briquet, I am led to the conclusion that *Oxy-*

polis does not owe its peculiar structure to an adaptation to wet and dry periods, but that it is a true swamp or bog xerophyte in accordance with the generalization of Schimper, who supposes that the water of bogs and swamps contains such a large proportion of humic acid as to render absorption difficult. Plants growing in such places therefore have difficulty in securing a requisite supply, as if growing under arid conditions. Not all plants are capable of absorbing water from a mixture exhibiting a higher pressure than that of the cell-sap of the absorbing organs.

Dr. Shaw * has pointed out that the vegetation of a pond in its final stage is always xerophytic and has drawn attention to the fact that the continual deposit of organic material around the margin of a pond will produce a zone so much filled with humic acid as to be entirely devoid of vegetation. Dr. Cowles † has upheld this view of the xerophytic character of an undrained swamp and has frequently noted the remarkable assemblage of xerophytic adaptations such as leathery or hairy leaves and special structures for water absorption exhibited by the flora of peat bogs. In confirmation of this standpoint Dr. Cowles has pointed out that if plants growing in swamps of this type are xerophytic we ought to find them thrving in dry regions. And this he reports to be true; *Clethra alnifolia*, *Spiraea tomentosa* and *Myrica cerifera*, generally conceded swamp plants, have been found thriving and in all respects normal on dry hillsides.

As Briquet has indicated, the most superficial examination of the plant brings to light the unmistakably xerophytic character of the reduced leaf-surface and the strong development of hypoderm. On the other hand many of the characters which Briquet regards as demonstrating the hydrophytic nature of the plant, seem when viewed in the light of recent ecological work, to be adaptations either for water storage or the prevention of transpiration. The large thin-walled empty celled endoderm certainly exhibits capacity for water storage. The thick cuticle and the waxy incrustation of the epidermis, the accessory cells and the sunken position of the stomata, and the presence of resin glands all point to the conclusion that the conservation of water is the chief purpose met by the striking structural adaptations.

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* Shaw, C. H. The Development of Vegetation in the Morainal Depressions of the Vicinity of Wood's Hole. Bot. Gaz. 33 : 437. 1902.

† Cowles, H. C. Bot. Gaz. 27 : 293. 1899.

This view is strengthened by the experimental results. Two series of cultural tests were made. In one series a number of plants in pots of soil were enclosed in bell-jars and were thus grown in a saturated atmosphere. Others were entirely submerged in tanks of water. The phyllodes produced under these conditions were similar. In both cases these organs were delicate, hollow, terete, translucent, light green in color, and exhibited no trace of glands or pits. The stipules were membranous and reduced in width. The epidermal cells were without wax or cuticle and were greatly elongated longitudinally. The stomata were partly exserted and were of a reduced number, but retained their characteristic structure. In consequence of the regularity of the epidermal

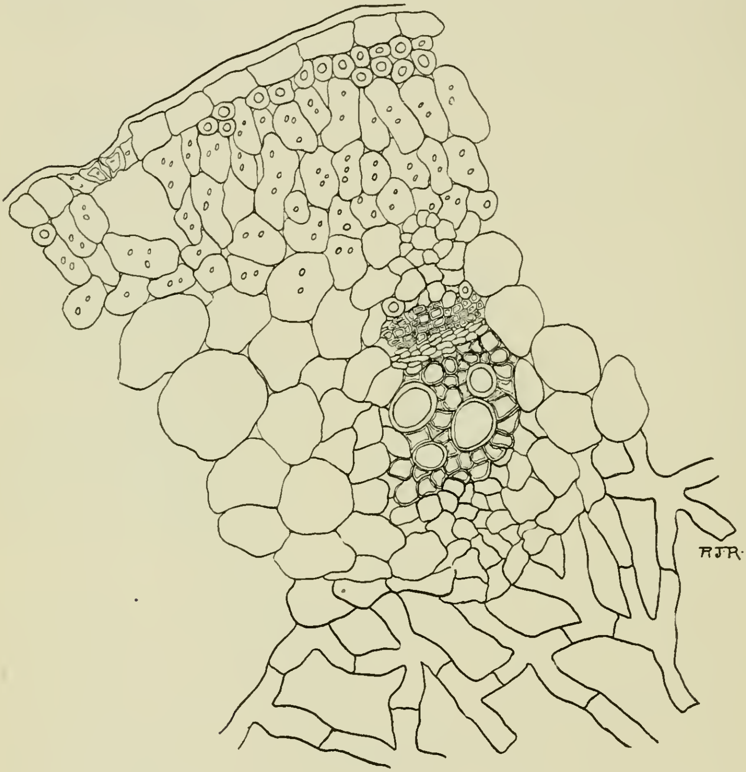

FIG. 2. Partial cross-section of phyllode, xerophytic form, × 140.

rows of cells, the stomata occurred in definite rows separated from each other by five sterile epidermal rows. Hypoderm was absent. The chlorophyl-cells followed directly upon the epidermis. This tissue was reduced to about three rows, and the palisade character of the first row of cells was not very marked. The endoderm was also less developed. It consisted of only one to three rows of cells. The stellate tissue of the other form was entirely absent here. As a consequence of the meager development of endoderm the fibro-vascular bundles jutted out into the central cavity. The xylem in the bundles was reduced and the position of the resin duct changed. In the normal type it was always to be found outside of the phloëm; in these phyllodes it was on the other side of the bundle near the xylem. This position of the duct has been pointed out by Van Tieghem as more primitive or juvenile. The diaphragms were composed entirely of thin-walled cells and the anastomosing bundles contained in them were much weaker and, contrary to the habit in the solid phyllode, anastomosed as freely at the center of the septum as about the edge. No trace of glands in the phyllode have been found and there is consequently no general convergence of bundles toward any single point in the margin.

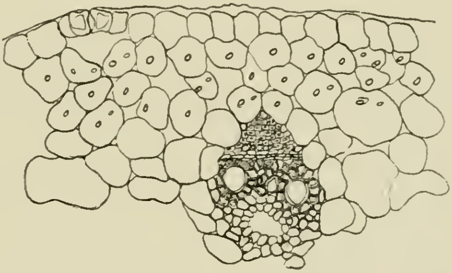

FIG. 3. Partial cross-section of phyllode, hydrophytic form, × 140.

The phyllodes of the submerged plants possessed in all cases the same structure as those grown under the bell-jar and exhibited an additional modification in their method of propagation. New plants were developed from the nodes of the xerophytic stems which had been developed before the plants were submerged and also in turn from the nodes of plants produced under water.

The water in which the immersed plants were grown presented none of the difficulties of absorption of the liquid in bogs. These submerged individuals as well as those in the bell-jars were seen to undergo true aquatic adaptations consisting in the loss of hypoderm of the central stellate tissue and of the glands; the reduction of the chlorophyl-bearing elements, of the endoderm, and of the number of stomata as well as of the xylem; the change in the position of the resin duct; the modification of the epidermal cells, stomata, cells of the septa and the course of the bundles through the septa; and the adoption of a new method of propagation.

These changes may be divided naturally into two classes, those which involve a suppression of xerophytic characters and those which are a means of adaptation to moist conditions and therefore hydrophytic in their nature. In the first class we must consider the loss of hypoderm and glands, the reduction of palisade-cells and water-storage tissue of the endoderm and the loss of cuticle; while we find in the modification of the epidermal cells, the reduction and modification of the stomata and the adoption of a new method of propagation types of structure peculiarly distinctive of hydrophytes. If the action of water free from high concentration of osmotic substances will induce such sweeping departures from the normal, it seems but reasonable to conclude that the plant is naturally a swamp xerophyte.

The adaptations described seem to have been most thoroughly adopted by the species since the characteristic structure of the phyllodes is to be found in the seedlings. These seedlings were raised from seed developed by the plants with which the experiments were made. The cotyledons were flat and linear in shape and 5 to 6 cm. in length. When the first leaf developed it exhibited the typical awl-shaped, septate character and bore glands and the accompanying scales along one side throughout its length. In internal structure it also resembled the later leaves in all respects, except that the hypoderm was absent and that the cells of the endoderm bore chlorophyl.

The chief results of importance brought out in the foregoing paper may be briefly summarized as follows:

1. The leaf-structures of *Oxypolis filiformis* are terete, awl-pointed phyllodes with numerous septa or diaphragms, and this form is exhibited even by the first leaf of the seedling. The

structure of the septa as examined by myself differs notably from that described by Briquet.

2. The phyllodes normally bear numerous glands sunk in pits which are edged with a minute scale. These glands are on a line at 90° from the plane of the stipules and the attendant scales may not be considered as vestigial leaflet structures as suggested by Goebel as to the scales of *Crantzia.*

3. Plants of *Oxypolis filiformis* when grown in a saturated atmosphere or under the influence of normal soil-water (submerged) exhibits marked hydrophytic adaptations of the phyllode. The changes ensuing under such circumstances emphasize stili further the xerophytic character of the phyllodes as indicated by their anatomical character, and reënforce the conclusion that this species should be regarded as a swamp xerophyte.

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 41

THE POLYPORACEAE OF NORTH AMERICA—V. THE GENERA CRYPTOPORUS, PIPTOPORUS, SCUTIGER AND PORODISCUS

By WILLIAM ALPHONSO MURRILL

NEW YORK
1903

[Reprinted from the BULLETIN OF THE TORREY BOTANICAL CLUB, 30: 423–434. August, 1903]

The Polyporaceae of North America.—V. The Genera Cryptoporus, Piptoporus, Scutiger and Porodiscus

By William Alphonso Murrill

The most important groups of the genus *Fomes*, as this term is generally used, have been treated in the preceding papers of this series. The plants heretofore considered are, for the most part, perennial, with large stratified sporophores which grow conspicuously upon the dead or dying wood infested by their very active mycelium. The present paper deals chiefly with species found under the genus *Polyporus* in Saccardo. These plants are annual and their fruit-bodies are less conspicuous than those of the former group, while their mycelium is usually comparatively limited in extent. Most of the species here discussed are terrestrial and somewhat fleshy, being allied to the Boletaceae. These terrestrial species are exceedingly rare and beautiful in North America, and present an interesting problem in distribution. The genus *Porodiscus* introduces the wood-loving forms of the genus *Polyporus*, which will form the subject of another article.

Cryptoporus Shear, Bull. Torrey Club, **29**: 450. 1902

The name *Cryptoporus* was first used by Peck (Bull. Torrey Club, **7**: 104. 1880) to designate a new section of the Placodermei made necessary by the discovery of a species of *Polyporus* having a volva. His description of the section is as follows:

"Pileus at first subcarnose, becoming harder or corky, sessile or stipitate, the margins greatly prolonged beyond and beneath the

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[The preceding number of the Bulletin, Vol. 30, No. 7, for July, 1903 (30: 369–422), was issued 10 Jl 1903.]

mouths of the pores and wholly or partly concealing them from view, generally opening beneath by a small aperture; pores not stratose, the dissepiments thickened at the mouths and there differently colored."

In raising this section to generic rank, Shear cites Peck's description and the description of the single species contained in the section following, with a brief discussion of varieties and several additional collections from new localities.

CRYPTOPORUS VOLVATUS (Peck) Shear

Polyporus volvatus Peck, Rep. N. Y. State Mus. **27**: 98. 1877.

Polyporus obvolutus Berk. & Cooke, Grevillea, **7**: 1. 1878.

Fomes volvatus Cooke, Grevillea, **13**: 119. 1884.

Cryptoporus volvatus Shear, Bull. Torrey Club, **29**: 450. 1902.

This peculiar plant was described from specimens collected on *Abies nigra*. It is also found rarely on *Abies balsamea*, but seems to prefer species of pine, upon which it is quite common. I have seen dead trunks of *Pinus rigida* filled with the mycelium, the fruit bodies emerging through holes made by beetles. It is possible that the specimens found on charred wood in the West are larger than our Eastern plants because no effort is required to reach the surface through a heavy layer of cortex. Torrey's stipitate Western form figured by Gerard is duplicated at times in the East when the plant grows on the top of a log. Henning's variety *Helix* from California is fully described by Peck and differs in no way from the type, which had not been seen when the variety was described. Peck's varieties *obvolutus* and *Torreyi* seem hardly worthy of separation. *P. evolvens* Berk. & Cooke, Herb. Berk. 1879 from California, fastened to a sheet of *P. evolutus* B. & C., is only *P. volvatus* and is very distinct from *P. evolutus*.

EXSICC.: California, *Harkness*, *Torrey*, *McClatchie*; Colorado, *Crandall*, *Shear & Bessey*; Oregon, *Shear*, *Carpenter*; West Virginia, *Nuttall*; New York, *Murrill*; Michigan, *Robbins*; British Columbia, *Macoun*; Delaware, *Commons*; District of Columbia, *Shear*, *Hicks*.

PIPTOPORUS Karst. Rev. Myc. 3: 17. 1881

This genus was originally established upon a single species, *Polyporus betulinus* (Bull.) Fr., and has since remained monotypic.

It is chiefly distinguished from nearly related genera by its separable hymenium, which, upon investigation, is found to be cut off from the context proper by a thin flesh-colored layer of mycelium connected very loosely with the adjacent layers and allowing them to separate easily. In age this layer disintegrates and the tubes fall away in irregular masses, leaving the smooth white surface of the context conspicuously exposed.

PIPTOPORUS SUBEROSUS (L.) Murrill

Boletus suberosus L. Sp. Pl. 1176. 1753.
Boletus betulinus Bull. Herb. France, *pl. 312.* 1786.
Polyporus betulinus Fr. Syst. Myc. **1**: 358. 1821.
Piptoporus betulinus Karst. Rev. Myc. **3**: 17. 1881.
Piptoporus suberosus Murrill, Jour. Myc. **9**: 94. 1903.

Pileus fleshy to corky, compressed ungulate, convex above, plane below, attached by a short umbo behind, varying to bell-shaped when hanging from horizontal trunks, 5–30 × 5–20 × 2–5 cm.; surface smoky, covered with a thin separating pellicle, glabrous, devoid of markings, cracking with age; margin velvety, concolorous, obtuse, projecting beyond the hymenium nearly a centimeter: context fleshy-tough, elastic, homogeneous, 3 cm. thick, milk white; tubes separated from context by a thin pink layer, 0.5 cm. long, 2–3 to a mm., sodden white; mouths very irregular, dissepiments thicker than pores, obtuse, entire, crumbling away in age, leaving the smooth white context: spores white, cylindrical, curved, 4–5 μ in length.

This plant is confined to species of birch, upon the dead or decaying trunks of which it is quite abundant in the northern United States and Canada. Its common occurence in Sweden explains why it was noticed and described by Linnaeus in Flora Suecica as early as 1745. From the following selected exsiccati it will be seen that this species is as cosmopolitan as its hosts. France, *Roumeguère 2102;* Germany, *Sydow 627;* Saxony, *Krieger 907;* Sweden, *Romell 10, Murrill;* Russia, *Jaczewski 76;* Wisconsin, *Baker;* New Jersey, *Murrill;* New York, *Underwood, Murrill;* New Hampshire, *Miss Minns, Grout.*

SCUTIGER Paul. Icon. Champ. *pl. 31. f. 1–3.* 1793

Seven species were included in this genus by Paulet, one of them an agaric, four hydnums and two polypores. The first species listed and described is *Scutiger tuberosus* Paul., later changed to *Polyporus asperellus* by Leveillé, a well-known European species belonging to the section *Ovini* of Fries and to the genus *Polyporus* of Karsten and *Caloporus* of Quélet. *Albatrellus* of S. F. Gray, another synonym of *Scutiger*, antedates the two last mentioned by more than half a century. Plants belonging to this genus are central-stemmed, fleshy-tough and terrestrial with white flesh, rounded pores and smooth, hyaline spores. Some of the members of this group approach the closely related genus *Boletus*, but are firmer, tougher and more lasting.

As to distribution, the species of *Scutiger* are, in general, limited to rather small areas; few of them are common, some are rare and local, and, so far as known, European and American species are entirely distinct. The indications are that the plants lack vigor and are easily affected by soil, climate and other environmental conditions. *Polyporus poripes* Fr. was placed in this group before the plant was fully known. Mature specimens show that it belongs rather with multiplex forms such as *Polyporus frondosus* under the genus *Grifola*. A somewhat older stage of *P. poripes* was described by Berkeley and Ravenel in 1872 as *P. flavovirens*.

Synopsis of the North American Species

1. Surface of pileus uneven, squamose or rugose. 2.
Surface of pileus smooth, tomentose or glabrous. 4.

2. Pileus sulfur-yellow, pleuropus, surface ornamented with imbricated floccose wart-like scales, context white or yellowish, tubes small, angular, decurrent, white, becoming greenish when wounded, yellowish when dry, spores 9 × 6 μ. 1. *S. Ellisii.*
Pileus brown. 3.

3. Tubes large, 1.5 mm. or more in diameter, hexagonal, surface of pileus smoky-brown ornamented with darker imbricated tufts of appressed hairs, context white, stipe excentric, its entire surface reticulate. 2. *S. retipes.*
Tubes small, 0.5 mm. in diameter, polygonal, decurrent, white, pileus reddish-brown, rugose, stipe central, not reticulate. 3. *S. decurrens.*

4. Pileus light-colored, white, red or blue. 5.
Pileus dark-colored, gray or brown. 7.

5. Pileus white, context white, tubes irregular, dissepiments thin, white, plants small, growing upon grass roots, stipe short, dark-brown. 4. *S. cryptopus.*
Pileus red, glabrous, stipe short, concolorous, context rose-colored, tubes short, small, 1–2 × 0.2 mm., decurrent, orange-colored, spores ovoid, hyaline, 4 × 5–6 μ. 5. *S. laeticolor.*
Pileus blue when fresh, changing to brown on drying. 6.

6. Tubes entire, becoming reddish-brown on drying, context ochraceous and pileus and stipe reddish-brown in herbarium specimens. 6. *S. caeruleoporus.*
Tubes lacerate, fading to grayish-brown or dirty white, context nearly white, pileus and stipe dull smoky-brown when dry. 7. *S. holocyaneus.*

7. Stipe black and rooting. 8.
Stipe neither black nor rooting. 9.

8. Pileus smoky-brown, subtomentose, margin thin, inflexed, context white, tubes regular, polygonal, entire, 2 mm. long, 0.5 mm. in diameter, stipe cylindrical, light-brown above, black and rooting below, spores white, elliptical, 7 × 5 μ. 8. *S. radicatus.*
Pileus drab-colored, nearly glabrous, margin thin, inflexed when young, context milk-white even when dry, tubes white, irregular, toothed, 1 mm. long, 0.25 mm. in diameter, stipe short, sooty-black as far as the decurrent tubes, attached to buried wood, spores white, 3-4 × 5–7 μ. 9. *S. subradicatus.*

9. Pileus gray, glabrous or nearly so, margin very thin, context rosy-gray, soft, fleshy, thin when dry, tubes small, 0.25–0.5 mm., unequal, decurrent, stipe short, concolorous. 10. *S. griseus.*
Pileus brown. 10.

10. Stipe dark purple, very thick, pileus fulvous-brown, purplish at times, clothed with short tomentum, margin very obtuse, context reddish beneath the cuticle, marked when dry with a black concentric line limiting growth, tubes white, 2 to a mm. 11. *S. persicinus.*
Stipe yellowish-brown, usually excentric, plants caespitose, pileus yellowish-brown, pruinose, margin thin, context rose-tinted when dry, dark red next to the tubes, which are small, 1–3 × 0.3 mm., decurrent, rose-colored when dry, the edges fimbriate. 12. *S. Whiteae.*

1. **Scutiger Ellisii** (Berk.)

Polyporus Ellisii Berk. Grevillea, **7**: 5. 1878.

Polyporus flavosquamosus Underw. Bull. Torrey Club, **24**: 84. 1897.

This plant was first collected by Ellis in low woods near Newfield, New Jersey. In 1886 only two specimens of it were known to Ellis, the one just mentioned and one collected in South Carolina by Ravenel. In 1897 it was found in Alabama by Mrs. Earle and redescribed by Underwood as *P. flavosquamosus.* The specimen thus described was growing on clayey soil in pine woods and was large and of advanced age, for it was in February that it was found. Very young plants of this species were collected in the same locality by Bradford in December, 1900, which measured over three inches across, emitting when fresh a "strong unpleasant odor." The indications are, judging from the meager knowledge at our command, that this attractive species is at home in the gulf states and grows but sparingly above the Carolinas.

2. **Scutiger retipes** (Underw.)

Polyporus retipes Underw. Bull. Torrey Club, **24**: 85. 1897.

The type collection of this species was made in Alabama in 1897 by Mrs. F. S. Earle. The plants were found in autumn growing on the ground in pine woods. Collections were made later in Alabama by Earle and Baker. In color and stature this species resembles specimens of *Polyporus ovinus* sent from Upsala to Kew, but the pores are very much larger and the species are very distinct.

3. **Scutiger decurrens** (Underw.)

Polyporus decurrens Underw. Bull. Torrey Club, **24**: 83. 1897.

This is a very distinct species, about which little is known. The type plants were collected by Dr. Hasse near Pasadena, California, growing in the soil on the side of a cañon. The collection was made in February, 1896, and no new collections of the species have been reported since.

4. **Scutiger cryptopus** (Ell. & Barth.)

Polyporus cryptopus Ell. & Barth. Erythea, **4**: 79. 1896.

A very distinct and interesting species found by Bartholomew in Kansas attached to dead grass roots in sandy pastures. The name refers to its habit of lying flat on the ground and thus concealing the stipe, in which position the pilei look like small whitish discs.

5. **Scutiger laeticolor** sp. nov.

A thick central-stemmed plant of rather large size with a smooth red pileus and orange-colored tubes. Pileus circular in outline, depressed at the center, 10 × 10 × 1 cm.; surface glabrous, brick-colored to purplish-red, margin acute, at first inflexed, irregularly undulate: context fleshy-tough, pale rose-colored, homogeneous, 0.75 cm. thick; tubes 1–2 mm. long, 5 to a mm., decurrent, rather dark orange throughout, mouth subcircular or polygonal, dissepiments thin, toothed at times, especially when decurrent: spores ovoid, smooth, hyaline, copious, 4×5–$6\ \mu$: stipe short, thick, increasing upward, 2 × 1–2.5 cm., resembling the pileus in color, but solid, firm and tough, with darker flesh.

The above description is made from a rather old and somewhat faded dried specimen collected by Underwood in Alabama in

November, 1895, and now in the Underwood herbarium. Although the description is on this account unsatisfactory, the plant is nevertheless very distinct and must be highly attractive when seen at its best. The only other plant of this species that I have seen is one at Kew sent by Ravenel under the name *P. confluens*. This specimen however, does not figure in my description, since I have made no special study of it. Like most of the other members of the genus, this species is doubtless rare and probably confined to the states south of Virginia. The appearance of the stipe indicates that it is terrestrial, growing unattached in soil rich in humus. The name I have chosen for it refers to its brilliant coloring throughout.

6. **Scutiger caeruleoporus** (Peck)

Polyporus caeruleoporus Peck, Rep. N. Y. State Mus. **26**: 68. 1874.

EXSICC.: New York, *Peck*, *Ellis*; Vermont, *Morgan*; North Carolina, *Atkinson*.

This rare and beautiful species is found on the ground in woods during midsummer. In sheltered spots the whole plant is externally grayish-blue in color, the blue fading gradually to gray upon exposure. Specimens have been found with one half of the pileus exposed and faded, while the other sheltered half was normal. In drying, the blue color disappears, being retained longer in the hymenium than in the surface of the pileus. It was from partially faded specimens that the plant was first described. Herbarium specimens in the Ellis collection are fulvous with darker hymenium and ochraceous flesh. How long the grayish-blue color remains after drying I cannot tell.

7. **Scutiger holocyaneus** (Atk.)

Polyporus holocyaneus Atk. Jour. Myc. **8**: 117. 1902.

This species was collected near Blowing Rock, North Carolina, by Atkinson and Troyer in September, 1901. Several plants were found growing gregariously on the ground beneath coniferous trees. When fresh they were entirely blue, but in drying the color changed to dull brown. In this and several other respects the species resembles *Scutiger caeruleoporus*, from which, however, it is quite distinct.

8. **Scutiger radicatus** (Schw.)

Polyporus radicatus Schw. Proc. Acad. Sci. Phila. **4**: 155. 1834.

Polyporus Morgani Peck, Rep. N. Y. State Mus. **32**: 34. 1879.

Polyporus Kansensis Ell. & Barth. Erythea, **4**: 1. 1896.

EXSICC.: Ohio, *Lloyd*, *Morgan*; Indiana, *Underwood*; New York, *Overacker*; Canada, *Dearness*, *Macoun*; Kansas, *Bartholomew*.

This species is found from September to November in woody earth or on much-decayed wood about stumps or dead trunks. It is large and conspicuous and is quite easily recognized by its brown cap, large pores and long stipe, which is black and radicate at the base. The species ranges from Pennsylvania north to Canada and west to Ohio and Kansas, where it has been twice renamed. A specimen from Washington agrees with this plant in many respects, but has a darker, rougher pileus and firmer substance, with some differences in pore-structure. I hesitate, however, to describe it as new without more material, since *S. radicatus* is somewhat variable even in its type locality.

9. **Scutiger subradicatus** sp. nov.

A rather large thin plant with light brown almost glabrous surface, small white serrated tubes and short black stipe. Pileus irregular in outline, convex to plane, 12 × 9 × 0.5 cm.; surface fibrillose, drab-colored to isabelline, margin very thin, inflexed when young, irregularly undulate at maturity: context fleshy-tough, 1–7 mm. thick, pure milk-white even when dry; tubes mere areoles at first, short and small at maturity, scarcely 1 mm. in length, 3–4 to a mm., decurrent to the blackened part of the stipe, white, yellowish when dry, mouths polygonal, regular, at length much elongated by confluence or otherwise irregular, edges thin, toothed or fimbriate when mature: spores ovate to ellipsoidal, smooth, hyaline, not abundant, 3–4 × 5–7 μ: stipe short, thick, central, tapering and attached at the base, sooty-black up to the pores, 4 × 2.5 cm.; context milk-white, firm, fleshy-tough, surface minutely tomentose, rugose-reticulate when dry.

Two young plants of this species were collected by Dearness at London, Canada, in September, 1896, and a finely developed plant was recently found in New York by Mrs. M. L. Overacker. The three plants form a perfect series in development. All grew attached to decaying wood beneath the soil. The pores are not rounded and punctiform when very young, but large and areolate like those of *Merulius*, the short walls being built up from these ridges like the cells of a honey-comb without increasing in diameter. At first glance, one would say that this species is a peculiar form of *S. radicatus*, but a little investigation shows that it is quite distinct. Because of this superficial resemblance, however, I have assigned to it the name given above.

10. **Scutiger griseus** (Peck)

Polyporus griseus Peck, Rep. N. Y. State Mus. **26**: 68. 1874.

Polyporus Earlei Underw. Bull. Torrey Club, **24**: 84. 1897.

Exsicc.: New York, *Peck;* New Jersey, *Ellis*, *Stevenson;* Alabama, *Earle.*

This species has been found on the ground in open deciduous woods in New York and New Jersey and in pine woods in Alabama. It is the only member of the genus that has been collected in any quantity. Its place in the American flora is very much the same as that occupied by *P. leucomelas* in Europe, though the two species are certainly distinct.

11. **Scutiger persicinus** (Berk. & Curt.)

Polyporus persicinus Berk. & Curt. Grevillea, **1**: 37. 1872.

Little is known of this plant beyond the original description in Grevillea and a longer one by the same authors in the Centuries of North American Fungi. It was first found by Ravenel in South Carolina growing at the base of trunks in pine woods. A study of the type at Kew shows it to be a very distinct species, while its large size and dark brown or purple color must make it conspicuous among related species when seen in the fresh state. While bearing an outward resemblance to *P. Schweinitzii*, its context and pores are white when fresh, changing to gray when dried, and this color is uniform, except for a black line showing in cross-section as a limit of growth for a certain period. The margin of the pileus is very obtuse and lobed or quite irregular from confluence.

12. **Scutiger Whiteae** sp. nov.

A plant of medium size, growing in clusters, with yellowish-brown pileus and tubes that are white when fresh and rose-colored when dry. Pileus subcircular in outline, convex, depressed at the center, 8–12 × 0.5–1 cm.; surface pruinose, velvety to the touch, isabelline to fulvous, margin acute, at first inflexed, irregularly undulate at maturity: context fleshy-tough, 0.2–0.5 cm. thick, of nutty flavor, rose-tinted when dry, dark red next to the tubes; tubes 0.1–0.3 cm. long, 3 to a mm., very decurrent, white when young and fresh, rose-colored when bruised or dried, mouths circular or subcircular, edges thin, fimbriate: spores ovoid, hyaline, smooth, copious, 3.5 × 5 μ: stipe short, usually excentric, enlarged at the base, 3 × 2–4 cm., concolorous, tough: plants caespitose, often confluent at the base, all stages of development being found in one cluster.

A fine collection of this species was made by Miss V. White at Bar Harbor, Maine, in August, 1901. The plant was found growing among moss on a damp river bank and seemed to her to resemble *Hydnum repandum* in general habit. Accompanying the specimens are excellent field notes and drawings in water colors.

Plants sent to Kew as *P. ovinus* by Farlow from New Hampshire seemed to me to agree with Miss White's specimens, but no special study of them was made. A few other stray American plants in foreign herbaria lead me to think that this species may possibly range as far south as Ohio, but that its proper home is in New England.

Porodiscus gen. nov.

Hymenophore small, annual, tough, epixylous, erumpent from the lenticels of dead branches; stipe attached to the vertex of the pileus, usually curved at maturity; context white, fibrous, tubes cylindrical, short, one-layered, mouths constricted; spores globose, smooth, hyaline.

The type of this genus is *Polyporus pocula* (Schw.) Berk. & Curt., first described by Schweinitz as *Peziza pendula* and later as *Sphaeria pocula.* By Fries it was first assigned to the genus *Cyphella* and later formed the basis of the new Friesian genus *Enslinia*, which name, however, was preoccupied by *Enslinia* Rchb. The fruit body matures slowly and resembles a discomycete in its early stages, hence the confusion in regard to its systematic position. The name I have chosen for the genus refers to this resemblance. There is only one species known.

Porodiscus pendulus (Schw.)

Peziza pendula Schw. Syn. Fung. Car. 92. no. 1183. 1818.

Cyphella pendula Fr. Syst. **2**: 203. 1822.

Sphaeria pocula Schw. Proc. Acad. Sci. Phila. **4**: 189. *pl. 2. f. 6.* 1834.

Enslinia pocula Fr. Summ. Veg. Scand. **2**: 399. 1849.

Polyporus pocula Berk. & Curt. Proc. Am. Acad. Arts & Sci. **4**: 122. 1859.

Polyporus cupulaeformis Berk. & Curt. Grevillea, **1**: 38. 1872.

This species has been much confused because of its similarity to members of other groups. Schweinitz at first called it *Peziza digitalis* Alb. & Schw. (Consp. Fung. 315, no. 943. *pl. 5. f. 1.* 1805), a European plant which it outwardly resembles, but in publishing it he adds "nisi nova, minor, durior, *pendula* a me nominata." That this name *pendula* was unpublished previous to this time is indicated by the fact that he cites this as the place of its publication under *Cyphella pendula* in Proc. Acad. Sci. Phila. **4**: 184. 1834. That it was in common use may be judged from the fact that Fries got it in manuscript from Schwaegrichen, a friend of Schweinitz and the editor of his work on the fungi of Carolina.

When Schweinitz received more mature specimens of the same species from Dr. Torrey collected on branches of ash, he named it *Sphaeria pocula*, at the same time stating that the plant was entirely similar to his *Cyphella pendula*, except for the presence of perithecia. A southern form on sumac was later named *Polyporus cupulaeformis* by Berkeley and Curtis. The confusion that has arisen is partly due to the small size of the plant and the changes that take place in it as it develops. On emerging from the bark of its host it is erect, sessile and depressed at the center without the appearance of a *Polyporus*. Later, the central depression is occupied by a porous hymenium and a stipe develops, which varies in length and is more or less curved according to its position on the branch. The surface could hardly be called tomentose, but is uniformly covered with a brown powder, which bleaches and partly disappears in age.

As to locality and host, this species shows little choice, being found on dead branches of chestnut, oak, hickory, sumac, red cedar and other trees from New England to Florida. I have found it very common on dead branches pruned from chestnut trees in the woods and parks about New York City. Some of these branches are entirely infested with the fungus, even to the smallest twigs. According to Schweinitz, it was also common on chestnut around Bethlehem, Pennsylvania.

Specimens examined: Rav. Fung. Car. 10, 210, Ell. & Ev. N. A. Fung. 308, 2728, Rabenhorst-Winter Fung. Eur. 3328 (from America); Georgia, *Ellis*; South Carolina, *Ravenel*; Florida, *Calkins*; West Virginia, *Nuttall*; Missouri, *Demetrio*; Pennsylvania, *Ellis*; New Jersey, *Ellis*, *Murrill*; Delaware, *Commons*; Connecticut, *Thaxter*.

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A REVISION OF THE FAMILY FOUQUIERIACEAE

By GEORGE V. NASH

NEW YORK
1903

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A Revision of the Family Fouquieriaceae

By George V. Nash

During an attempt to identify one of the species of *Fouquieria* which flowered in the conservatories of the New York Botanical Garden during the past June, much confusion was found to exist, both in the identification of herbarium material and in the literature bearing upon this family. So great was this confusion that the writer was eventually compelled to extend his examinations beyond the point he had anticipated, and finally realized that a revision of the family was necessary before any definite results could be obtained. No recent treatment, involving a consideration of the species, could be found, and the apparent need of such work encouraged the author to enter upon the following revision, which, it is hoped, will throw some light upon an interesting family and one but little understood. As here regarded, it embraces two genera and seven species, three of which are here described for the first time.

The relationship of the family is rather puzzling, and a satisfactory solution of the difficulty has not as yet been proposed. By Bentham and Hooker (Gen. Pl. **1** : 161) it was made a tribe of Tamaricaceae, and the same treatment was accorded to it by Engler and Prantl (Nat. Pfl. 3^6: 298). Subsequently Engler (Nat. Pfl. Nachtr. 251) maintained that the family was better kept separate from Tamaricaceae on account of its oily endosperm and gamopetalous corolla. Its distribution would also tend to confirm this distribution of the group, for Tamaricaceae, with Fouquieriaceae removed, is strictly Old World, while Fouquieriaceae itself is confined to North America, and primarily to its arid regions.

While Engler changed the rank of this family, he indicated no change in its relationship. It is hardly within the scope of a revision of this kind to discuss at length a matter of this nature, but the strong resemblance in many ways to certain forms of the Polemoniaceae cannot be passed by without some comment. In this connection it is well to remember that it was in this family, as a *Cantua*, that the original species was published. The 3-celled ovary, the more or less united styles and the gamopetalous tubular corolla, to the base of which the filaments are slightly adnate, all markedly point in this direction. The spongy central column found in the dehiscing capsules would indicate that the inner edges of the septa unite. A transverse section of the ovary made at this time, and before the septa break away from the walls, would much resemble the condition of things existing in the genus *Gilia*, also found in the same region. The general resemblance of the flowers to those of some of the large-flowered red Gilias is perhaps the most striking feature of the plants. It is true that the sepals in this are distinct, while in *Gilia* they are more or less united, but this is but one character weighing against many others. It would seem to me that the ovarian, placental, style and corolla characters indicate a strong affinity with that family, much stronger than with the Tamaricaceae, to which family, polypetalous in all its other forms as are its immediate relatives, the gamopetalous corolla of Fouquieriaceae does violence.

FOUQUIERIACEAE DC. Prod. 3: 349. 1828.

Shrubs or trees, the trunks simple, columnar and stout, or much branched: branches spine-branching. Spines developed within the petioles of the leaves on the new growth and becoming apparent when these fall. Leaves with the blades flat, entire, or rarely obcordate or emarginate: those on the young growth petioled, the petioles from one half as long as to equalling the blade. Secondary leaves borne in fascicles in the axils of the spines and sessile or nearly so. Inflorescence spicate to paniculate, terminal. Flowers sessile or pedicelled. Calyx of five free imbricated sepals. Corolla yellow or red, hypogynous, the segments united for one half their length or more: tube cylindric, sometimes broadened toward the apex: lobes flat or concave, imbricated in the bud, incurved, erect, spreading, reflexed or enrolled. Stamens ten to fifteen, of unequal length, exserted from the corolla-tube, and adnate to it at the very base: filaments subulate, usually broadened and compressed dorsally at the more or less pubescent base where they are sometimes coherent, sometimes provided with a scale-like appendage near the base: anthers acute at the apex, cordate at the base, elliptic to nearly ovate, introrse, versatile, attached below the middle, 2-celled, the cells opening longitudinally. Ovary 3-celled, the inner edges of the septa united at the base and at the very apex, free in middle, the septa finally uniting by the inner edges and breaking away from the walls, forming a central column attached at the apex and at the base. Ovules 4–6, in two rows, in each cell, borne on the edge of the free portion of the septa. Styles 3, slender or stout, included in or exserted from the corolla, united only at the base or for their entire length. Capsule dehiscing loculicidally, 3-valved, the valves thick and coriaceous. Seeds oblong, compressed, at first broadly winged, the wing finally breaking up into long filaments similar to those on the body of the seed. Albumen thin, oily. Cotyledons flat, oblong to ovate, cordate at the base. Radicle short.

Genera two, both natives of Mexico, one, *Fouquieria*, also found in the adjacent parts of the United States. The *Idria* of Kellogg is often united with *Fouquieria*, but it seems more natural to keep it separate, both on account of habital characters and differences in the flowers. The short stout included styles united for their entire length, yellow flowers and columnar, normally unbranched trunk, justify this treatment.

Styles more or less united, but free at the apex, exserted, the column and branches slender: shrubs or trees with branching trunk: corolla red. 1. *Fouquieria.*
Styles wholly united, stout, short, included, forming a 3-angled stout body: tree with a stout columnar undivided trunk: corolla yellow. 2. *Idria.*

1. FOUQUIERIA H.B.K. Nov. Gen. & Sp. 3: 452. 1820

Bronnia H.B.K. Nov. Gen. & Sp. 6: 83. 1823.

Philetaeria Liebm. Vidensk. Selsk. Skr. V. 2: 283. *pl.* 1851.

Shrubs or trees with spicate or paniculate inflorescence and red sessile or pedicelled flowers. Sepals less than one half as long as the corolla-tube. Corolla red, cylindric to campanulate, the segments united into a tube for one half their length or more, the tube sometimes gradually enlarged toward the apex: lobes from erect to recurved or enrolled. Stamens ten to fifteen, more or less broadened and compressed dorsally at the pubescent base. Styles slender, exserted, united only at the base, or nearly to the apex.

Species six; Mexico and the adjacent parts of the United States.

Inflorescence corymbiform-paniculate. 1. *F. fasciculata.*
Inflorescence conic to elongated paniculate, or spicate.
  Corolla-tube cylindric, several times longer than the lobes.
    Inflorescence spicate. 2. *F. formosa.*
    Inflorescence paniculate.
      Filaments unappendaged: panicle conic to ovate: bushy shrubs or trees.

Corolla-tube 3–4 mm. in diameter: sepals oval: panicle-branches slender. 3. *F. Macdougalii.*

Corolla-tube 5 mm. in diameter: sepals orbicular: panicle-branches stout. 4. *F. peninsularis.*

Filaments with a scale-like appendage near the base: panicle long and narrow: shrubs with long slender simple branches. 5. *F. splendens.*

Corolla campanulate, the tube about equalling the lobes. 6. *F. campanulata.*

1. **Fouquieria fasciculata** (R. & S.)

Cantua fasciculata R. & S. Syst. **4**: 369. 1819.

Fouquieria spinosa H.B.K. Nov. Gen. & Sp. **3**: 452. 1820.

Bronnia spinosa H.B.K. Nov. Gen. & Sp. **6**: 84. *pl. 528.* 1823.

Cantua spinosa Willd.; H.B.K. Nov. Gen. & Sp. **6**: 84. 1823.

Echeveria paniculata Mocino & Sessé; DC. Prod. **3**: 350. 1828.

A tree 4 m. tall or more, with white fragile wood and round glabrous spiny branches. Leaves fascicled in the axils of the spines, obovate-oblong, rounded at the apex or sometimes emarginate, cuneate at the base, glabrous, shining, about 2.5 cm. long and 9–10 mm. wide: panicle terminal, corymbose, much-branched, its branches glabrous: capsule about 1 cm. long: sepals nearly orbicular, about one fourth as long as the capsule: seeds oblong, compressed, the margin membranous-winged, the inner surface concave, the outer convex, brown, glabrous, the wings nearly entire, emarginate at the apex and at the base; episperm thinly membranous, adhering to the endosperm which is thin and fleshy; embryo included, straight, almost as long as the endosperm, compressed; cotyledons leafy, ovate, obtuse, cordate at the base, fleshy; radicle cylindric, somewhat acute, one third as long as the cotyledons.

The above description is drawn from the original in the work of Humboldt, Bonpland and Kunth, cited above. I have seen no specimens of this species, but its corymbiform panicle is unlike that of any of the others. The type material was in fruit only, and was secured at Puente de la Madre de Dios, at an altitude of about 5,280 feet. This place is somewhere in the neighborhood of Mexico City or Actopan, but it has not been possible for me, up to the present time, to locate it more definitely.

It is interesting to note here that this is the type of *Fouquieria*, a monotypic genus at that time, which was based on *Cantua fascic-*

ulata R. & S. (although H.B.K., for no apparent reason, credit it to Willdenow). Subsequently *Fouquieria* was again published, this time being based on an entirely different plant, *F. formosa*, and at the same time *F. spinosa*, alluded to above, was made the type of the new genus *Bronnia*. The genera are, therefore, synonymous, *Fouquieria* taking presence on account of the priority of publication.

2. FOUQUIERIA FORMOSA H.B.K. Nov. Gen. & Sp. **6**: 83. *pl. 527*. 1823.

Echeveria spicata Mocino & Sessé; DC. Prod. **3**: 349. 1828.

Philetaeria horrida Liebm. Vidensk. Selsk. Skr. V. **2**: 283. *pl.* 1851.

A branching shrub 2–3 m. tall, with a racemose inflorescence and large red flowers. Leaves on the new growth 3–4 cm. long, petioled; petiole about one half as long as the blade; blade 2–2.5 cm. long, 10–13 mm. wide, elliptic, apiculate, cuneate at the base: fascicled leaves in the axils of the spines smaller, sessile or nearly so, elliptic, 1.5–3 cm. long, usually less than 1 cm. wide, rounded at the apex, cuneate at the base: spike 1.5 dm. long or less, the flowers ascending: sepals red, 8–11 mm. long, broadly oval to orbicular: corolla red, the tube a little curved, cylindric, about 2 cm. long and about 7 mm. in diameter, the lobes spreading or reflexed, orbicular, abruptly acuminate, 6–8 mm. long: stamens exserted, unequal in length, sometimes twice as long as the corolla, the filaments a little broadened and compressed below, glabrous at the base, then pubescent for a short distance with long ascending hairs, the remainder of the filament glabrous, the anthers oblong-ovate, cordate at the base, acute at the apex, 5–6 mm. long: styles united except at the apex, shorter than the longest stamens, the divisions 3–5 mm. long.

Southern Mexico.

Specimens examined. — Jalisco: Guadalajara, *Pringle 2420*, 1889. Puebla: Tehuacan, *Pringle 6296*, 1895. Mexico: Chiquihuite, *Bourgeau 1120*, 1865–6.

This is quite distinct from any of the other species in its spicate inflorescence. The exact locality from which it was originally secured is not indicated. The specimens cited above would point to the southern part of Mexico as its home. *Philetaeria horrida* Liebm. was obtained in valleys at an altitude of 1500–1800 meters, in the district of Tehuacan, State of Pueblo, from which place Pringle also secured the same plant many years later. Liebmann's excellent plate and description leave no doubt as to the identity of his plant with the one of H.B.K.

3. **Fouquieria Macdougalii** sp. nov.

A much-branched tree, reaching a height of 7 m. and a trunk diameter of 1–2 dm., with bark yellowish green on the trunk and brown on the spiny branches, the spines 1–2 cm. long, and terminal slender panicles of few bright red flowers. Leaves on the new growth 6–8 cm. long, petioled; blade 3.5–4 cm. long and about 1 cm. wide, acute at the apex, and rather abruptly narrowed into a petiole of the same length: fascicled leaves in the axils of the spines gradually narrowed into a sessile base, 3.5–4 cm. long and about 1 cm. wide: panicle slender, 7–10 cm. long, its delicate simple branches widely spreading, the lower ones 3–4 cm. long and bearing 2–4 flowers on slender pedicels which are 1–2 cm. in length and abruptly thickened at the apex: flowers few: sepals broadly oval, about 6 mm. long, the outer two acute, the inner three rounded and apiculate at the apex: corolla about 2.5 cm. long, the tube cylindric, 3–4 mm. in diameter, the lobes broadly ovate, erect, acute, about 5 mm. long: stamens 10, exserted, the filaments red above, white below, broader and dorsally compressed near the base, the interior surface of this compressed portion glabrous, the exterior surface pubescent with long stout hairs which gradually increase in length upward and extend but a short distance on the rounded part of the filament which is glabrous to the summit, the anthers 2–3 mm. long: styles exceeding the stamens, united almost to apex: capsule about 2 cm. long.

Type specimen from living plants, collected at Torres, Mexico, in 1902, by MacDougal, no. 28, which flowered in the conservatories of the New York Botanical Garden in June, 1903.

Sonora and Sinaloa.

Specimens examined. — Sonora: Rayon, *Thurber 952*, 1851; Torres, *MacDougal 28*, 1902; Alamos, *Palmer 306*, 1890; Granados, *Hartman 226*, 1890. Sinaloa: Culiacan, *Palmer 1804*, 1891.

This plant was first secured by Thurber at Rayon, about eighty miles north of the place where it was recently obtained by Dr. MacDougal. Thurber's plant was distributed as *F. spinosa*, from which it differs materially. It is evidently, however, the plant referred to under that name in the preface to Gray's Plantae Novae Thurberianae (Mem. Am. Acad. Arts & Sci. II. 5: 303). His description of this tree agrees with a photograph of one made by Dr. MacDougal. The trunk arises from the ground for two or three feet, and then divides into crooked branches, the ultimate divisions of which are pendulous.

4. **Fouquieria peninsularis** sp. nov.

Bronnia spinosa Benth. Voy. Sulph. 16. 1844. Not H.B.K. 1823.

A shrub 2–3 m. tall, with a conic panicle and red flowers. Leaves on the new growth 5–6 cm. long, petioled: petiole about 3 cm. long, about as long as the blade: panicle conic, 1.5 dm. long or less, its branches ascending, stout, the lower ones sometimes 4–6 cm. long and usually divided, bearing 2–4 flowers on the ultimate divisions in a rather crowded manner, on short stout pedicels usually less than 5 mm. long: sepals orbicular or nearly so, 5–6 mm. long, apiculate, reddish: corolla red, the tube slightly if at all curved, about 1.5 cm. long and 5 mm. in diameter, the lobes erect or nearly so, orbicular, acute, 5–6 mm. long: stamens exserted, unequal in length, the filaments broadened and compressed at the base, the inner surface of the compressed portion glabrous, the outer surface pubescent with long ascending hairs, the remainder of the filament glabrous, the anthers 3–4 mm. long: styles united except at the apex: capsule fully 2 cm. long.

Lower California and western Sonora.

Specimens examined. — Lower California: La Paz, *Maj. W. Rich*, Dec. 11, 1847 (type); Turtle Bay, *Anthony 144*, July–Oct., 1896; San Bartolome Bay, *Chas. F. Pond*, March, 1889; Calmalli, *Purpus 141a*, Jan.–March, 1898; Cape San Lucas, *Xantus 38*. Sonora: Guaymas, *Palmer 266*, 1890.

Related to *F. splendens*, but distinguished by the absence of the appendage at the base of the filaments, the more open panicle and the larger capsule.

I have ventured to identify the *Bronnia spinosa* of the Voyage of the Sulphur with this plant, as I have seen material from Cape San Lucas, the place from which that plant was secured. The type of this species was secured at La Paz, only about ninety miles north of Cape San Lucas. Bentham describes the filaments as glabrous, a condition unknown in the genus so far as I have examined it. Otherwise his description agrees well with this plant, and as the filaments are pubescent only toward the base the pubescence might readily be overlooked.

5. FOUQUIERIA SPLENDENS Engelm. in Wisl. Mem. Tour Mex. 98. 1848.

Fouquieria spinosa Torr. in Emory, Mil. Reconn. 147, *pl. 8.* 1848. Not H.B.K. 1820.

A branching shrub, the long slender branches arising from near the base, sometimes to a height of 4–6 m., with a narrow paniculate inflorescence and red flowers. Leaves of the new growth 3–5 cm. long, petioled; petiole about one half as long as the blade; blade 2–3 cm. long, 5–7 mm. wide, narrowly elliptic to oblanceolate, acute at the apex, narrowed at the base: fascicled leaves 1–1.5 cm. long, 5–8 mm. wide, narrowly obovate to obcordate: panicles narrow, solitary or several at the apex of the stem, 5–20 cm. long, the branches usually short and with the few flowers crowded: sepals broadly oval to nearly orbicular, 5–8 mm. long, obtuse or rounded at the apex: corolla red, the tube straight, 15 18 mm. long, gradually a little enlarged toward the apex, 4–5 mm. in diameter at the middle, the lobes spreading and recurved or enrolled, broadly oval to orbicular, obtuse at the apex or sometimes apiculate, 4–5 mm. long: stamens exserted, unequal in length, the filaments broadened and dorsally compressed at the base, the compressed portion running out laterally into a scale-like appendage which is pubescent on the upper surface and 0.5–1 mm. long, the inner surface of this broadened portion glabrous, the outer surface pubescent with long stout hairs, the remainder of the filament glabrous; anthers about 4 mm. long, oblong, abruptly acute, cordate at the base: styles more or less united, only toward the base, or nearly to the apex: capsule 1–1.8 cm. long.

Western Texas and northern Mexico to southern California and northern Lower California.

Specimens examined.—Texas: El Paso, *G. R. Vasey*, May, 1881, and *L. H. Dewey*, June 15, 1891; *Wright 228*, October, 1849. Mexico: Chihuahua and Sonora, *Thurber 401*, May, 1851; Coahuila, *Palmer 80*, 1880; San Pablo, *Gregg*, April 30, 1847. New Mexico: Grant Co., *Mearns 46*, 1892; Little Mt., near Las Cruces, *Wooton*, May and July, 1893. Arizona: Tucson, *Toumey*, April 20, 1894; Tucson Mts., *Toumey 465*, 1892; Willow Springs, *Jones*, May 29, 1890; Gila Valley, *Rothrock 319;* foothills, *Prin-*

gle, April 6, 1891 ; San Francisco Mts., *Wheeler*, 1872 ; Squaw Peak, *Mearns 173*, May 6, 1887 ; Ft. Huachuca, *Wilcox*, June 1, 1892, and *106*, 1894. California : *Emory*, November 29, 1846 ; *Frémont*, 1849 ; The Needles, *Jones 3831*, May 6, 1884 ; southern California, *Parish*. Lower California : Rosario, *Orcutt 1354*, May 1, 1886.

This species has a much more extended range than any of the others and is the only one found within the confines of the United States. It may be distinguished at once from narrow-panicled forms of *F. peninsularis* by the prominent appendage near the base of the filaments and by the larger capsule. It has a number of common names, among them being Ocotillo, Coach-whip, Vine-cactus, and Jacob's Staff.

6. **Fouquieria campanulata** sp. nov.

A woody plant with narrow panicle and red campanulate flowers. Leaves on the new growth 3–4 cm. long, petioled ; petiole less than one half as long as the blade, which is 2–3 cm. long and 4–5 mm. wide, narrowly oblong or oblanceolate : fascicled leaves 2–3 cm. long, 3–6 mm. wide, oblanceolate, acutish, narrowed to the sessile base : inflorescence a narrow panicle 1.5 dm. long or less, the branches short and spreading and the flowers on them crowded : sepals broadly oval to orbicular, 5–6 cm. long, pale : corolla, from the tip of the recurved spreading lobes to the base of the tube, 12–14 mm. long, campanulate, the tube, which is about as long as the lobes, 3 mm. broad at the base, enlarging to the summit where it is 5–6 mm. in diameter : stamens exserted, unequal in length, the filaments broadened and compressed at the base, the broadened portion running out into a spreading or reflexed scale-like appendage which is pubescent on the upper surface and about 0.75 mm. long, the inner surface of the compressed portion glabrous, the outer surface pubescent with long hairs toward the summit, the remainder of the filament glabrous, anthers ovate-elliptic, cordate at the base, acute at the apex.

Durango.

Specimens examined.—Santiago Papasquiaro, *Palmer 87*, 1896.

An exception in the genus in having campanulate flowers. This and *F. splendens* are the only species which have well-developed appendages toward the base of the filaments.

2. IDRIA Kellogg, Hesperian, 4 : 101, *pl.* 1860

Trees with a stout columnar trunk from which arise short spreading spiny branches. Inflorescence paniculate, arising from the apex of the trunk, the flowers rather crowded and almost sessile upon the ultimate divisions of the panicle. Corolla yellow, campanulate, the lobes orbicular, concave, incurved, shorter than the tube. Stamens 10, adnate at the very base to the corolla-tube: filaments pubescent below. Styles short, thick, united their entire length, but little longer than the ovary, forming a stout 3-angled body, the angles rounded.

Species one; Lower California.

1. IDRIA COLUMNARIS Kellogg, Hesperian, **4**: 101. *pl.* 1860.

Fouquiera columnaris Kellogg; Curran, Bull. Cal. Acad. Sci. **1**: 133. *pl.* 1885.

Fouquiera gigantea Orcutt, West Am. Sci. **2**: 48. 1886.

A tall tree with a tapering trunk up to 3–4 m. in height or even taller, and a diameter at the base of about 3 dm. or more, from which arise the short spreading spiny and leafy branches. Leaves of the new growth unknown: fascicled leaves 1.5–2 cm. long and 5–8 mm. wide, oblanceolate to narrowly obovate: panicles 3–4 dm. long, flowers rather crowded and nearly sessile upon the ultimate divisions: flowers, including the exserted stamens, 12–14 mm. long: sepals orbicular, about 4 mm. long: corolla yellow, 6–7 mm. long: stamens exserted, the filaments pubescent below, the anthers about 3 mm. long: styles about 2 mm. long, thick.

Lower California.

Specimens examined. — Rosalia Bay, *Anthony 120*, July to October, 1896.

Originally collected by Dr. Veatch near the Bay of Sebastian Viscaino, on the mainland east of Cedros Island. The tree was described by Dr. Kellogg as spineless, but this must have been an error, as others who have visited the same region remark upon the long spines which are found on the short branches arising from the trunk. Moreover, a specimen in the herbarium of the New York Botanical Garden, collected by Anthony at Rosalia Bay, but a few miles north of the original station, shows these spine-bearing branches, the spines being similar to those occurring in the other members of this family. Dr. Kellogg describes the trunk as undivided, while Orcutt, in the description of his *Fouquiera gigantea*, states that the trunk branches above the middle, sending up a few simple branches to nearly the height of the main stem. Brandegee, in his account of a collection of plants made in Lower California in 1889 (Proc. Cal. Acad. Sci. II. **2**: 132, 133), also refers to this branched condition, but considers this state as exceptional and due to accident or injury. Both Brandegee and Orcutt claim the trunk attains a height of fifty feet or more. Brandegee remarks that the old capsules are 8–10 mm. long and sessile in the panicle, and that the trunks are 6–9 dm. in diameter at the base, gradually tapering upward into a pointed apex, so that the general shape is much like that of an inverted carrot.

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SOME CORRELATIONS OF LEAVES

By DANIEL TREMBLY MACDOUGAL

NEW YORK
1903

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Some Correlations of Leaves

By Daniel Trembly MacDougal

As a result of a long series of experimental tests made in the New York Botanical Garden, Mr. Charles Zeleny has found that the excision of one of the leaflets of such plants as *Trifolium pratense* (clover), *Parthenocissus quinquefolia* (Virginia creeper) and *Lupinus albus* (white lupine) resulted in alterations in the positions of the remaining leaflets, alterations in the intervals between the remaining members and divergences from the normal size.

Our knowledge of correlations at the present time would lead to the expectation that organs, the activity of which was complementary or dependent upon a removed organ would show a decreased or diminished development. On the other hand the small amount of evidence available would have led to the generalization that the loss of an organ or a part of an organ would stimulate the development of the remainder of the organ, or of the tissues carrying on the same function, in a supposed effort to bring the total functional performance up to the normal average. Mr. Zeleny's results, however, demonstrate unequivocally that the excision of a leaflet in the above species is followed by a diminished development on the part of the remainder, which results in the accomplishment of a superficial extension, as represented by the length of the members, about seven per cent. less than the normal.* Results fairly in agreement with those of Mr. Zeleny have also been obtained by Nemeč by less exact methods.†

Goebel cites the fact that the stipels of the compound leaves of *Robinia Pseudacacia* (locust) reach an abnormally large size when the leaflets are removed, which is an example of the induced enlargement of a structure in the effort to carry out the functions of lost tissue.‡ He has also found that the destruction of the vegetative points on such leaves as those of *Bryophyllum* is followed by the formation of new ones at places nearer the base of the leaf-blades.* It is evident therefore that the epipodium, or laminar portion of the leaf, is capable of the most diverse correlative reactions according to the structure, and adaptive, or secondary functions it has acquired.

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* Read before the Botanical Society of America, Pittsburg, July 1, 1902. Now in press in Bull. N. Y. Bot. Garden, vol. 3, no. 9.

† Nemeč, B. Ueber die Folgen einer Symmetriestörung bei zusammengesetzten Blättern. Bull. Internat. Acad. Sci. Bohême. 1902.

‡ Goebel. Organography of Plants, 1 : 210. 1900.

The lack of uniformity in the facts at hand suggested that a repetition of some of the experimental tests with additional species might yield results of value. To this end the author made a series of observations upon the effect of the removal of the epipodium and mesopodium of the leaves of one species upon the stipules of the hypopodium and upon the vegetative points of the stems from which the leaves arose. Additional observations were carried out on the influence of the removal of a leaf showing only a distinct mesopodium (petiole) and epipodium (lamina) upon the vegetative points of the stem and upon the development and differentiation of the tissues of the stem.

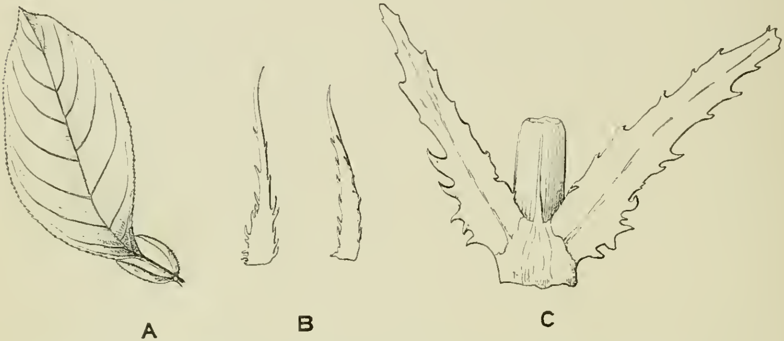

Fig. 1. *Prunus serotina*. A, normal leaf, × ½. B, normal stipules, × 3. C, leaf-base with enlarged stipules; the stump of the excised petiole is shown, × 3.

A small specimen of *Prunus serotina* growing near the propagating houses of the New York Botanical Garden was selected for the first test. All of the young unfolding leaves, except those of one basal branch, were dissected by the excision of the petiole near the stipules on April 24, 1903. None of the leaves had unfolded on the above date. The plant was visited daily and the successive leaves removed in the same manner leaving the stipules intact. A number of the other small trees of the same species growing near by were also available for comparison. The earlier part of the season was one of extreme drought. During the period of fifty-two days between April 16, a week before the beginning of the test, a total precipitation of only 1 cm. was recorded. It was noted that the scales and stipules were of longer duration and presented the appearance of increased superficial extension upon the delaminated branches within a fortnight after beginning the tests. The development of leaves and buds appeared to have almost ceased and an anatomical examination was made June 3–10 with the following results :

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* Goebel. Regeneration in Plants. Bull. Torrey Club, 30: 197–205. 1903.

The greatest length made by branches which had been defoliated from the beginning was 18 cm., while a length of 25 and 30 cm. was found in normal branches ; 18–20 leaves had been formed on defoliated branches and but 14 or 15 on normal ones. The basal internodes of the twigs showed but little difference in length in the two instances, being as much as 2 cm., although less in some cases. The internodes formed later in the season on the normal twigs attained a length of as much as 3.5 cm. in some instances, while those of the defoliated twigs varied from 1.5 cm. to one third that length. Consequently the defoliated twigs were closely crowded at the terminal part with scales and stipules. This crowding effect was accentuated by the fact that one or two small leaves were thrust out of the axillary buds, although no general activity of the bud was exhibited. In contrast with the behavior of *Acer*, it could not be made out that any extra number of lateral buds on the older parts of the branches below had been induced to awaken.

The correlative alterations in the stipules were very marked and consisted in changes in form, size, position, structure and period of endurance. Normal stipules of the cherry are thin-membranaceous, and generally of a reddish tinge containing almost no chlorophyl. These stipules are usually short-lived and fall off in such manner that on the above date they could be found only on two or three leaves on the terminal portions of twigs. The stipules on twigs on which the leaves had been dissected were both broader and longer, offering a superficial expansion of about five times the normal (see *f. 1*). The maximum measurements were but little greater than those of normal stipules formed earlier on the first internode, but their length, width and thickness was such as to give the exaggerated extension noted above when compared to correspondent structures on normal branches. Furthermore, three pairs of stipules were present on normal twigs and ten pairs on those which had been defoliated. It is thus to be seen that twigs which had been deprived of the laminar portions of the leaves made such development and retention of the stipules that they were able to expose about fifteen or sixteen times as much stipular surface as normal correspondent branches.

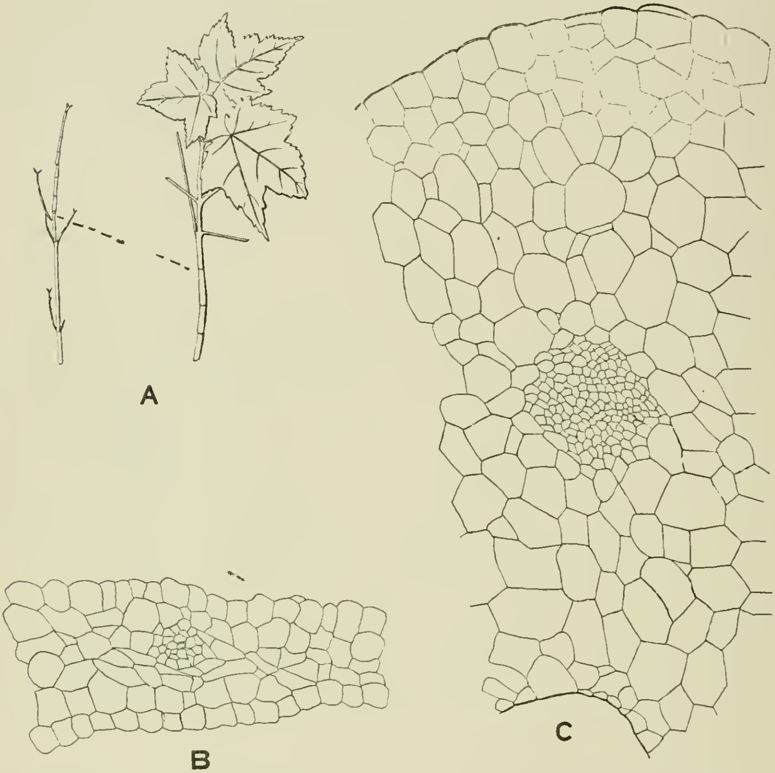

Fig. 2. A, *Acer;* normal and defoliated branches. The dotted line shows the bases of new growth. B, *Prunus;* transverse section of normal stipule. C, *Prunus;* transverse section of stipule of delaminated leaf. B and C are drawn to same scale.

The increase of the stipular surface consequent upon the removal of the laminae is not unknown, and Goebel notes that similar reactions are shown by the elder (*Sambucus nigra*).* He also found that the stipules of *Vicia Faba* were increased in superficial extension two to six times beyond the normal by the excision of the laminae in an early stage of development, and a similar exaggeration in the stipules of *Lathyrus Aphaca* resulted from the cessation of elongation or extension of the shoots. This correlation is not present in all plants, however, and not even in all Papilionaceae, since it was seen that the excision of the laminae of *Phaseolus multiflorus* had but little effect upon the size and structure of the laminae.†

The excision of the leaves of *Aristolochia*, in the course of the present experiments, did not cause any notable increase in size of the stipules as seen by general inspection, although no examination of the internal structure was made.

Kronfeld made a series of experimental tests of this matter in 1886, and found that the stipules of *Pyrethrum Indicum*, *Rosa semperflorens*, *Rubus fruticosus*, *R. Idaeus*, *Sida Napaea*, *Trifolium filiforme* and *Urtica urens* were not sensibly increased in size by the destruction of the laminae. The destruction of the laminae of *Pyrus Malus* was followed by an increase of the superficial expansion of the stipules amounting to a hundred per cent. The excision of the laminae of *Pisum sativum* was followed by an increase of the size of the stipules amounting to from fifty to one hundred per cent., while the excision of the stipules alone seemed to have the effect of causing earlier flower-formation. ‡

Stomata were found on both normal and abnormal stipules in *Prunus* in my own experiments. No examination of the number of stomata on the adjoining surfaces of the stem were made, but Braun has found that defoliation causes the formation of an increased number of these organs. § The enlargement of the stimulated stipules of *Prunus* had apparently not been accompanied by a multiplication of the epidermal cells, since these elements were both larger and wider in surface view than the normal.

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* Goebel. Organography of Plants, **1** : 210. 1900.

† Goebel. (Beiträge zur Morphologie und Physiologie des Blattes.) Bot. Zeitung, **38** : 836–837. 1880.

‡ Kronfeld, M. Ueber die "Correlation des Wachstums." Bot. Zeitung, **44** : 846–849. 1886.

§ Braun, K. Ueber Veränderungen im Gewebe entlaubter Stengel und Zweige. (Inaug. Diss.) Erlangen. 1899.

The enlarged stipules exhibited a thickness four or five times as great as the normal, chiefly due to increase in tissues and differentiations toward the structure of a typical lamina. A median layer of loosely arranged parenchymatous tissue contained much chlorophyl which was almost wholly lacking from the normal organ. This mesophyllary tissue also exhibited numerous intercellular spaces, and was altogether well adapted to carrying on photosynthetic and transpiratory functions.

The entire stipule, which is usually closely appressed to the petiole, was held at a more widely divergent angle than the normal. These adaptations have greater significance when it is understood that the total amount of stipular surface presented by a delaminated branch would amount to about fifteen or sixteen times as much as the normal. This comparatively normal increase, however, does not result in developing a foliar surface of more than one or two per cent. of that of the normal leafy branch.

Sections of the sixth internode from the base of the twigs formed in 1903 were examined in order to ascertain the effect of deprivation of the laminar structures and their partial replacement by the stipules. It has already been pointed out that the branches which had been delaminated had developed more internodes, the total lengths of which were less than of twigs normally grown, and had the appearance of being slightly thicker, but no measurements were made which might form the basis of an exact comparison. The epidermal tissues of the treated branch had greater radial and tangential diameters, and the underlying collenchymatous layers were but slightly thickened. The medio-cortex contained much more chlorophyl than the normal. The bast fibers were not so heavily thickened as in the normal, and the walls of all the internal tissues exhibited a slight yellowish tinge. The cambium showed a greater number of layers than the normal. The xylem was irregularly developed and seemed to have attained a less advanced stage of differentiation in its various elements than in the normal. The tangential development was notably deficient and the separate bundles were separated by wide rays of pith.

On June 15 the delaminated branches had assumed the appearance of a resting stage. The formation of leaves had ceased, and nearly all of the stipules had fallen off. The buds in the axils of the newly formed branches were enclosed and in the winter condition. My absence from the Garden during July prevented observations being taken during a period of four weeks, but an examination of the plants on July 30 showed that all of the newly formed delaminated branches of this season had perished and that buds on the older branches had awakened and extended to a length something less than the normal growth of the earlier part of the season.

The increase in the amount of chlorophyl in the cortex may be considered as a further effort to meet the losses ensuing from the lack of the laminar portions of leaves. The non-development of the phellogen and the imperfect construction of the bast fibers and fibrovascular bundles may be ascribed in part to a lack of formative material and in part to the absence of the stimulation ensuing from the decreased transpiration stream and the material usually formed in the laminae. In addition, the mechanical strains and stresses exerted by the foliar organs undoubtedly exert some stimulative effect on the rigidity and pliability of the stems by the induction of the development of various mechanical elements. The absence of stimuli of this character would account in part for the imperfect development of the stems.

The tests with *Acer* were much more restricted. The petioles were excised near the base and the effect upon the activity of the vegetative points noted. Only a single basal branch of a small tree was treated in this manner, and comparisons were made with corresponding portions of similar branches arising from the same part of the central stem.

The single normal branch taken for comparison developed four internodes which had a diameter about thirty per cent. greater than the internodes of the defoliated branch. The total length of the four newly formed internodes amounted to 78 mm., the longest being the third from the base of the yearly growth, measuring 25 mm. Eight active functional leaves were developed. (One has been cut away in the illustration, *f. 2, A.*) The newly-grown part of the defoliated branch measured 48 mm. and comprised seven internodes, the longest of which was the sixth from the base, measuring 8 mm. The excision of the leaves had induced the development of one bud in the axil of the last internode of the previous season. The branchlet thus formed showed two long internodes, the basal one of which measured 14 mm. Two branchlets were produced at the next node below on the newly-formed portion of the main branch, which showed two and three internodes and were 10 and 15 mm. long respectively. The third internode below produced two branchlets 6 and 12 mm. long and composed of two internodes.

The lateral branchlets of the main branch showed less total growth and also less marked development of the lateral buds correspondent to the general habit of the normal. Activity of the vegetative points on the defoliated and normal branches had practically ceased on June 15, the mutilated branch showing no prolongation of the period. The departures from the normal structure of the stem were fairly similar to those described in *Prunus*. Chlorophyl was quite as profusely developed in the normal as in the treated branch, however, and was found in the medullary rays in great abundance.

The above results are found to agree in the main with those of Boirivant, who practiced defoliation and delamination and noted the effect upon stems and upon petioles of *Faba vulgaris*, *Sarothamnus scoparius*, *Genista tinctoria*, *Lathyrus odoratus*, *Chenopodium album*, *Atriplex nitens*, *Linum usitatissimum*, *Galium Cruciata*, *Asparagus officinalis*, *Robinia Pseudacacia*, *Arachis hypogaea* and *Ailantus glandulosa*.* It is to be noted, however, that the epidermal tissues in my material showed enlargement in the tangential axis, and one or two other minor differences appear. Boirivant's studies included a consideration of the anatomy of the petioles of leaves of which the laminae had been cut away, and in these organs he found an exaggerated production of chlorophyl, modifications of the cortical tissues consisting of added differentiations of palisade tissue, and enlargement of the vessels and more lignification of the tracheids and pith. I am not able to find that he noted the effects of the treatment upon the stipels of *Robinia*, or made observations upon the reaction of the hypopodium especially.

The observations of Braun also extend over the matter of the effect of delamination on stems. His observations included

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* Boirivant, A. Recherches sur les organes de remplacement chez les plantes. Ann. Sci. Nat. Bot. VIII. **6**: 309–400. 1897.

Lamium Orvala, *Aconitum Stoerkianum*, *Clematis Vitalba*, *Syringa vulgaris*, *Corylus Avellana atropurpurea*, *Gillenia trifoliata*, *Prunus Mahaleb*, *Aesculus Hippocastanum*, *Ampelopsis hederacea*, *Aristolochia Sipho*, *Acer platanoides*, *Rosa centifolia* and *Phaseolus multiflorus*.* In addition to results previously cited, Braun concludes also that the effect of delamination is to increase the photosynthetic capacity of stems, retard the development of internodes and interrupt the formation of woody tissue, all of which is confirmed by my own results. Braun also suggests that the condition of delaminated stems may be regarded as pathological, and that it is directly due to mechanical interferences with the functions involved. The condition of delaminated branches is undoubtedly one of hypoplasia, but a careful consideration of the various features involved leaves but little doubt that the failure to develop is largely due to the absence of the customary stimuli in response to which the several tissues carry on growth and differentiation in a normal manner. The results in question are quite as much a matter of correlation dependent upon stimulative factors, as the variations in position and growth in compound leaves as discovered by Zeleny.

The more important facts observed as a result of cutting away the laminae of the leaves of *Acer* and *Prunus* by severing the petiole near the base may be briefly summarized as follows :

I. The duration of the stipules of *Prunus* is increased, so that ten pairs of these organs are to be found on branches at a time when only two or three pairs are present on a normal branch.

II. The stipular surfaces exposed on delaminated branches of *Prunus* were sixteen times as great as on normal branches.

III. The individual stipules of *Prunus* were of a maximum measurement in length and width on the delaminated branches and were much larger than the stipules present on the corresponding part of normal branches.

IV. The position of the stipules of *Prunus* on delaminated leaves was more divergent than the normal, and approximated that of a typical leaf.

V. The structure of the stipules of *Prunus* was modified in such manner as vastly to increase their capacity for photosynthesis and transpiration.

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* Braun, A. Ueber Veränderungen im Gewebe entlaubter Stengel und Zweige. (Inaug. Diss.) Erlangen. 1899.

VI. The loss of the lamina acts as a stimulus which induces a development and differentiation of spongy parenchymatous and other tissues in the stipule, and the formation of chlorophyl.

VII. The lateral buds of *Acer* on internodes formed during the previous season were awakened by defoliation of the extending apical portion.

VIII. The period of activity of the vegetative point of the terminal portion of a woody branch is not lengthened as a result of defoliation.

IX. The total length of the newly formed portion of the branches defoliated during growth was thirty to sixty per cent. less than that of normal branches occupying the same relative positions on the shoot.

X. The number of internodes developed on defoliated branches was greater than in the normal.

XI. The defoliated internodes were of a diameter not greater, sometimes less than the normal, and had accomplished less perfect differentiation.

XII. Branches compelled to accomplish growth in a defoliated condition generally are found to be in a state of hypoplasia, the undeveloped and imperfectly differentiated condition of the tissues being due to the lack of correlative stimuli.

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SOIL TEMPERATURES AND VEGETATION

By DANIEL TREMBLY MACDOUGAL

1903

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SOIL TEMPERATURES AND VEGETATION.

By Daniel Trembly MacDougal.

A committee on the relations of plants to climate was appointed at the New York meeting of the American Association for the Advancement of Science in June, 1901, to which was delegated the task of carrying out some work upon the relations of plants to various climatic factors. The actual investigations planned by the committee were entrusted to the author for execution, and a set of thermographs was put in action in northern Idaho in the summer of the same year in addition to the battery that was installed in the New York Botanical Garden. During the following year some thermometric observations were made in the Mission Mountains and Kootenai Mountains, in northern Montana, and a paper was presented at the meeting of the Association in Denver, August, 1901, describing a method of estimating the total temperature exposure of a plant which would be specially applicable and useful in measuring the influence of temperature upon the shoots of plants.

The basal portions of a typical plant, often the larger part of the body, are imbedded in the soil at various depths, and no adequate study of the influence of temperature upon physiological processes could be made until some accurate, graphic, and convenient method was devised for taking continuous records of the soil. The committee was given a second grant by the Association, and additional funds were also voted at the Pittsburg meeting in July, 1902. By the aid of additional contributions from the New York Botanical Garden efforts were made to devise an instrument that would meet the above needs. The committee was so fortunate as to enlist the active interest and practical cooperation of Prof. William Hallock, of Columbia University, who undertook to design a thermograph that would make a continuous record of the soil at any desired depth. A single working model was constructed in the autumn of 1901 and was tested for several months in Professor Hallock's laboratory before being installed in the Botanical Garden, May 2, 1902. A description of this instrument, together with the records obtained for May, 1902, have already been published.[1] It will be profitable to repeat this description here, together with the accompanying illustration (see fig. 1).

The thermal element of the instrument consists of a copper bulb or globe 11 centimeters in diameter (fig. 1, A), with a strengthening equatorial ridge of solid metal, filled with commercial kerosene. A short section of copper tubing with the walls flattened on two sides for convenience of manipulation during construction is soldered to a suitable opening in one pole of the copper globe, and the free end of the heavy tube is likewise soldered to a small copper tube with an external diameter of about 4 millimeters and an internal diameter of 1 millimeter. This tube is also filled with petroleum and may be of any reasonable length up to 10 meters or perhaps more without vitiating the accuracy of the instrument to any appreciable extent. Furthermore, in practise this tube may be variously bent and curved in making adjustments without detriment to the results obtained (fig. 1, C).

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[1] MacDougal. The temperature of the soil. Journal of the New York Botanical Garden. 3: 125-131. July, 1902.

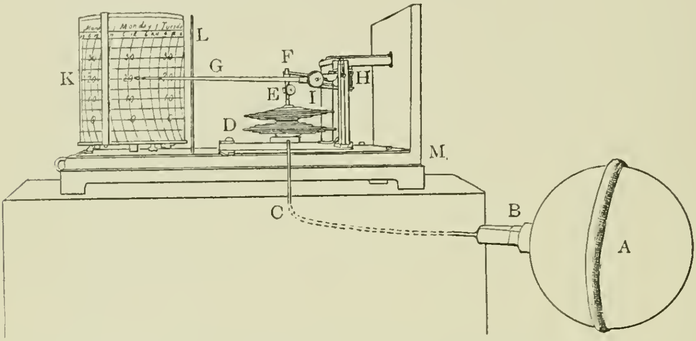

FIG. 1.—Hallock thermograph. A, bulb containing kerosene. B, heavy tube, soldered to polar opening in bulb. C, capillary tube connecting bulb with expanding chamber. D, double expansion chamber. E, upright post with adjustment clamp at E, on expansion chamber and fastened to short lever arm at F. G, lever extending from axis, and bearing pen, which traces temperature record on the cylinder. H, adjustment to raise or lower pen in making corrections and calibrations. K, cylinder driven by internal clockwork which makes one revolution per week. The cylinder carries paper ruled horizontally to degrees centigrade. The rate of movement carries the paper past the pen at such rate that two hours is taken to pass over the interval between two curved lines. L, upright rod on hinged base to remove pen from contact with paper. M, base of cast iron.

The free end of the capillary tube is connected through an opening in the side with the chamber in the interior of a solid brass block fastened to the base of the apparatus. Two pairs of convex, corrugated brass disks 8 centimeters in diameter are fastened together at the edges and the united pairs are then soldered together forming an expansion chamber composed of two disk-shaped cells, with an opening through the soldered portion (fig. 1, D). Next an opening is made in the center of one of the convex surfaces and this opening is joined by solder to the chamber in the brass block. The double expansion chamber is also filled with petroleum and care is taken to exclude all air from the tubes and chambers. The entire system is now seen to consist of a rigid bulb, tubes, and small base chamber terminating in an expansion structure which may dilate or contract with the alterations in volume of the fluid. It now remains to attach devices for properly demonstrating the movements of the upper wall of the expansion chamber in order to obtain the changes induced by variations in temperature. To do this an upright post is fastened to the upper wall of the expansion chamber and this is provided with a sleeve and set screw which allows adjustments of its length in connection with a lever (fig. 1, E and F) 4 centimeters long running to an axis held in bearings between two upright standards. A second arm 17 centimeters in length, bearing a suitable pen is attached to this axis and extends so as to come in contact with a suitable upright recording cylinder revolved by clockwork. The long lever is built up of three parts and is provided with a device for adjustment and calibration (fig. 1 H). The cylinder carries double ruled paper and makes a single revolution in a week. In the construction of the working model described here, it was found convenient to use the levers and recording mechanism of a thermograph of German manufacture, the slips of which were ruled for degrees centigrade. The instrument was calibrated to meet these requirements, but new models now under construction are designed on the Fahrenheit scale. The improved model may also be constructed to carry thermal apparatus for taking air temperatures on one end of the base and the soil temperatures on the other end, thus making synchronous records.

The peculiar value of the above apparatus consisted in the fact that the recorder could be kept in an instrument shelter of any convenient pattern and the sensitive bulb carried out and buried in the soil at any desired distance from the shelter, or at any depth in the soil, by which the actual temperatures encountered by the roots of plants might be obtained. In practise it was found that the amount of liquid in the capillary tube and expansion chamber was so small in proportion to that in the bulb that the temperatures encountered by the tube or chamber made no observable error in the reading of the instrument. This was true to such an extent that the flame of an alcohol lamp applied to the tubes did not produce any change in the position of the pen upon the recording slip. The same is true of the effects of direct exposure to the sun's rays.

The location for the installation of the instrument for the trial series of records for the first year was a small area of clayey soil mixed with loam lying near the propagating houses and nurseries in the New York Botanical Garden. The drainage is free, as the surface of the ground is slightly sloping to the eastward. During the summer the place is covered by the shade of some cherry trees after 4 p. m.

In the installation of the instrument the recorder, together with an air thermograph, was placed in an instrument shelter of the United States Weather Bureau pattern. The capillary tube passed through the floor of the shelter to the surface of the ground, being protected from mechanical injury by being placed in a grooved board. A narrow trench 2 meters long and about 20 centimeters in depth was dug and was then prolonged in a tunnel to a farther distance of 50 centimeters. This tunnel was only large enough to receive the bulb, and after that had been pushed to the farther end of the tunnel the excavated soil was packed around it in a manner as nearly natural as possible. By this arrangement the layer of soil above the bulb was left undisturbed and artificial drainage conditions were not introduced. This arrangement brought the upper surface of the bulb in contact with the soil penetrated by the matted roots of grasses and other small herbaceous plants, which also extended much deeper around the excavation.

The greater bulk or volume of the root system of the smaller plants usually lies nearer the surface of the soil than the position of the bulb of the thermograph, but the important function of absorption is carried on chiefly by the younger, most recently formed terminal portions of the roots which lie deeper in the soil. The rate at which mineral and other substances in solution in the soil are taken up, the permeability of the protoplasmic membranes, the turgidity and consequently the rigidity of the roots are also greatly affected by temperatures, while the growth of these organs, together with their endurance and that of all underground organs, depends not only upon the actual temperatures encountered, but also upon the rapidity with which changes ensue.

Before being placed in position the air thermograph and the soil thermograph were placed in a closed room with a standardized mercurial thermometer (No. 2792, G. S. Reichs-Anstalt, Berlin), and were found to read alike to within a small fraction of a degree, allowing for a slowness of response by the thermographs.

The records on hand now embrace a period of fourteen months, and the facts obtained seem to be of sufficient interest to warrant their discussion at the present time, together with some of the actual curves traced by the instruments.

It may be seen from these that the maximum daily temperatures occurred between 8 and 11 p. m., and the minima twelve hours later, or between 8 and 10 a. m. The optimum temperature for absorption by roots lies well above that of the soil at the depth at which the observations were made. It follows, therefore, that the temperature of the soil approaches this optimum most nearly, and offers most favorable conditions for the taking up of watery solutions at a time of the day when the amount of water thrown off by the shoot and of mineral matter used in metabolism are nearing the minimum by reason of the absence of light, lowered air temperature, and consequent increased humidity of the air. These inharmonious conditions account almost wholly for the profusion of guttation excretions or "dew drops" formed on the tips and margins of grass blades and leaves of low growing plants early in the evening. Absorption by the root continues quite vigorously after sunset by reason of the favorable temperatures, and the augmented amount of fluid in the cortex of the roots sets up a pressure which ultimately forces water into the central cylinder and up through the woody cells faster than it may be used and transpired by the thin-walled cells of the leaves. The vessels become filled with water which is forced out in liquid form through the excretory openings in the form of drops. In some species the amount of water coming away from the plant in this manner may reach quite an appreciable quantity.

On the other hand the forenoon witnesses the rapid acceleration of transpiration by all parts of the shoot at a time when the soil temperature is decreasing to a minimum. The increase of transpiration continues until mid-afternoon, while the temperature of the soil reaches a minimum two or three hours earlier and then begins to rise, but does not do so sufficiently to favor absorption to any great extent. It is true of course that the needs of the leaves may be partially met by the activity of the rootlets which lie nearer the surface.

The greatest amount of variation during twenty-four hours that was recorded during the year amounted to 2° C. (3.6° F.). This amplitude was shown on two occasions. June 28, 1902, the temperature rose from 8° C. (46.4° F.) at 10 a. m. to 10° C. (50° F.) at 10 p. m., in consequence of an increased temperature of the air, reaching a maximum of 27.8° C. (82° F.) at 1 p. m. The temperature of the soil fell from 12° C. (53.6° F.) at 11 p. m., on July 16, 1902, to 10° C. (50° F.) at noon on the following day. Curiously enough this minimum coincided exactly with that of the air a meter above the surface four hours earlier. A reverse movement of any kind greater than 1° C. has not been recorded within the limits of twenty-four hours. These slow changes in the temperature of the soil would exert no stimulative influence upon the action of the roots. Thus, for instance, a sudden and great diminution of the temperature of a root temporarily would increase the rate of absorption which, however, soon begins to decrease again. The least daily variations occurred during the winter months, when it did not exceed (1° C. (1.8° F.).

It is interesting to recall in this connection some of my own observations on the temperatures of the roots of small herbs and grasses in Arizona which were growing in volcanic sand. The observations were made by mercurial thermometers in 1898, and it was found that these organs were carrying on their functions under temperatures as high as 44° C. (111 + °F.) to 45.5° C. (114 °F.).

The general course of the temperature and the nature of the variations is shown by the accompanying tracings (see figs. 2 to 7) and the following data:

Temperatures of soil at a depth of 1 foot (30 centimeters) from June, 1902, to June, 1903 (degrees centigrade).

	1902.							1903.				
	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Maximum...	12.7	13.2	12.0	10.0	6.0	0.0	3.5	4.0	7.0	9.5	8.0	9.0
Minimum...	7.6	7.5	7.4	3.7	—1.5	—2.5	—3.0	3.0	5.0	7.0	4.0	6.0
Variation...	5.1	5.7	4.6	6.3	7.5	2.5	6.5	1.0	2.0	2.5	4.0	3.0

The maximum temperature for the year, 13.2° C. (56° F.), occurred in July, and the minimum, —3° C. (26.6° F.), in December, giving a total annual variation of 16.2° C. (29.4° F.).

When plants are cultivated in pots, in green houses, the small volume of soil around the roots responds much more rapily to changes in the temperature of the surrounding air and to the influence of streams and sprays of water than does the upper layer of soil in the open. In general the soil in the green house will show a much higher average temperature, which, with the other conditions mentioned, makes necessary special treatment on the part of the gardener. If the natural conditions of water supply by precipitation were complied with the needs of the plant would by no means be met under the altered conditions of temperature.

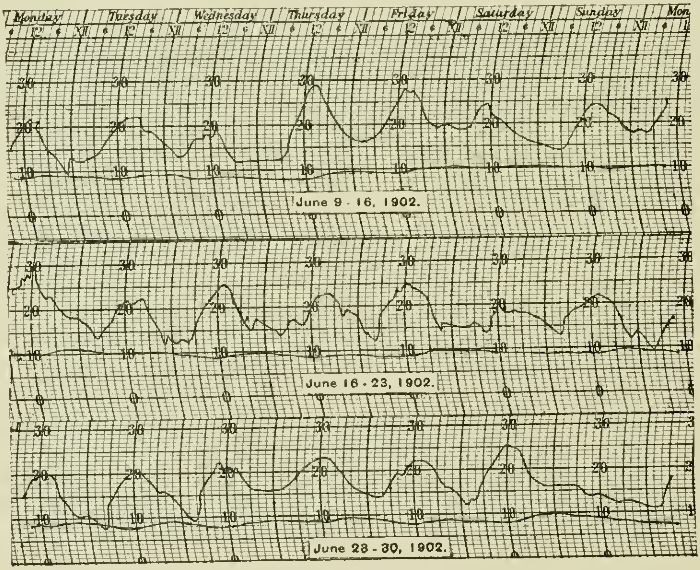

Fig. 2.—Tracings of thermographic curves of air, and of soil at a depth of 30 centimeters (1 foot), June 9–30, 1902. The daily periodicity and the direct effect upon the soil of changes in air temperatures are illustrated. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

Not the least interesting feature of the records are the data concerning temperatures during the winter months when vegetation is supposedly in a resting condition. The first general drop occurs early in September when the temperature is lowered 5° to 6° C. (9° to 10° F.). A month later a second general downward movement was noticeable, in October, which reached the freezing point on October 22. After a few days fluctuation about this point a decrease began which reached the annual minimum of —3° C. (26.4° F.) on December 10. A heavy snowfall was followed by a steady rise which carried the temperature above the freezing point on December 15. The total period during which temperatures below the freez-

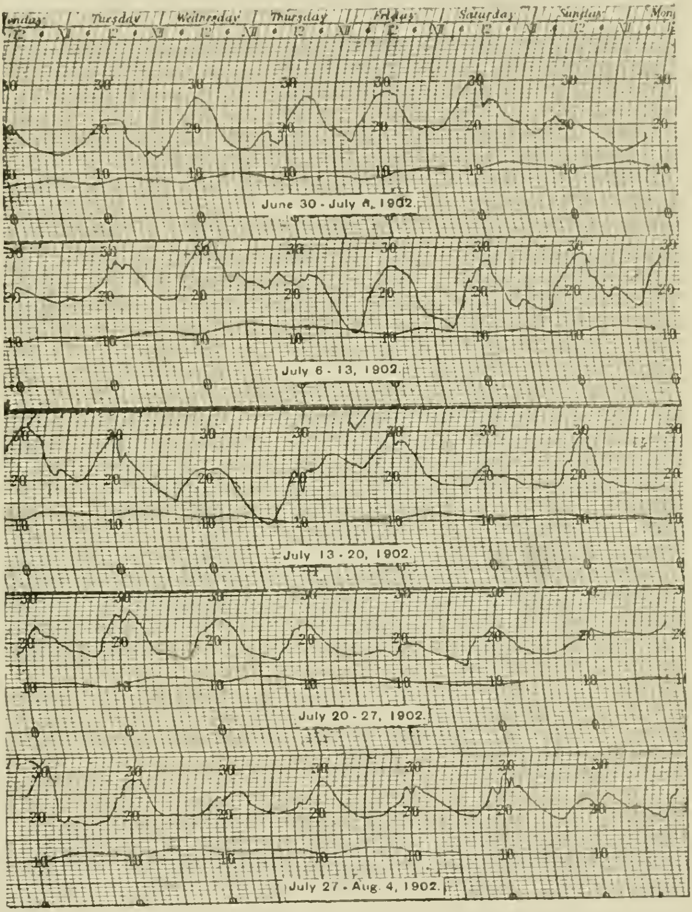

FIG. 3.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), June 30–August 4, 1902. The maximum temperatures of the year are included. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

ing point occurred included only fifty-four days, and the thermograph recorded freezing temperatures on but fifty days of this time. After the above date the rise was steady and continuous with minor fluctuations.

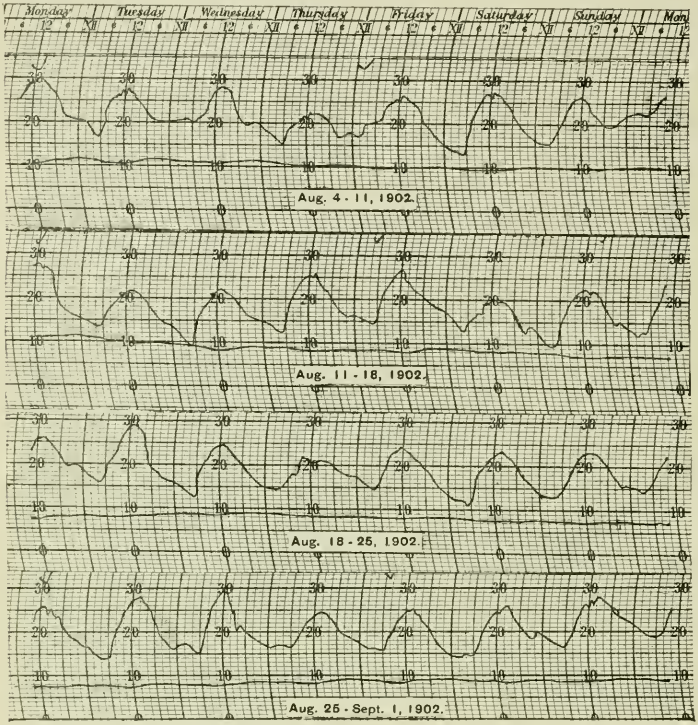

FIG. 4.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), August 4–September 1, 1902. A period during which comparatively little fluctuation and variation occurs. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

Both the maxima and minima are higher in January than in December and are still higher in February, at which time the temperature of the air reaches its annual minimum. As a consequence of the above conditions the roots of plants at a depth of a foot (30 centimeters) in this locality find increasingly more favorable conditions for activity after the latter part of December. Growth and division of the cells, and the attendant respiration would ensue in many species at an accelerated rate over that prevalent in the earlier months of the winter and the absorption of mineral and other compounds could take place to the utmost capacity of the plant. This will still be more apparent when it is seen that the temperature of the soil at a depth of a foot is but little lower in February than it is in April or May at a time when the growth and formation of new organs in the shoot is at a maximum. The approach of the spring season in this locality therefore finds the root systems and absorbing organs of the vegetation which penetrates the soil to the given depth in a state of comparatively great activity, and it needs but the exposure of a few days or even of a few hours in some plants to allow for very marked development of the stems, leaves, and flowers.

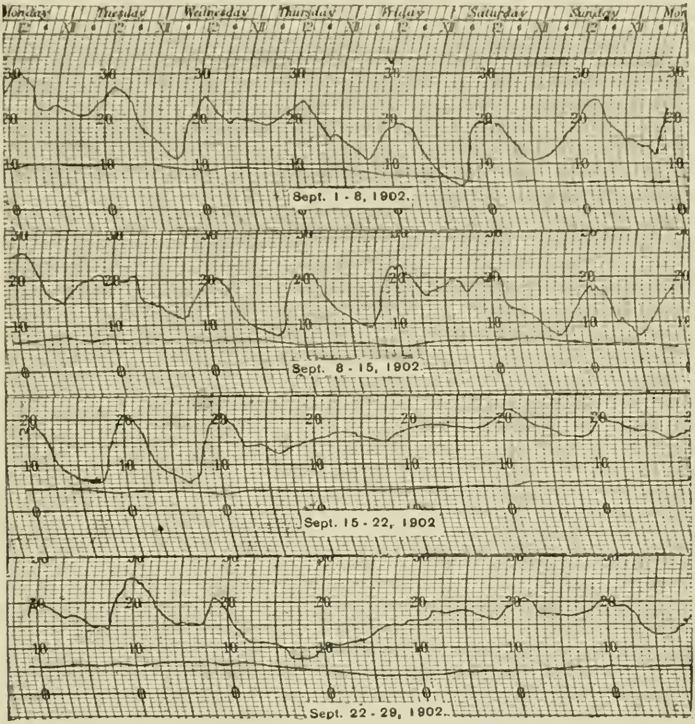

FIG. 5.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), September 1–29, 1902. A general decrease in the temperature of the soil amounting to about 5° C. was shown. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

Another point of interest in the present connection is the fact that such notable differences are found between the temperatures of the subterranean and aerial portions of the bodies of plants at almost all seasons. During June, 1902, the shoots of herbaceous plants were in an atmosphere that varied between 8° C. (46.5° F.) and 34° C. (92.5° F.), while the roots were between 8° C. (46.4° F.) and 13° C. (55.4° F.). As the maxima and minima were not synchronous the actual difference between the temperature of twigs and leaves on the upper part of the plant, and roots on the lower amounted to as much as 22° C. (nearly 40° F.) at certain times of the day. Such conditions occur, though slightly less accentuated, during the entire summer in this locality. It is evident without further discussion that such differences in the temperature conditions of the two poles of the plant must exert a more or less important influence on the transport of fluids and solutions from one part of the plant to another. Referring to the previous discussion concerning the comparative transpiration and absorption during the day it is to be seen that the heightened temperature of the shoot must operate in a simple physical way to greatly augment the amount of water thrown off while the roots must take in water at the same time to meet the loss at a temperature as much as 40° F. lower.

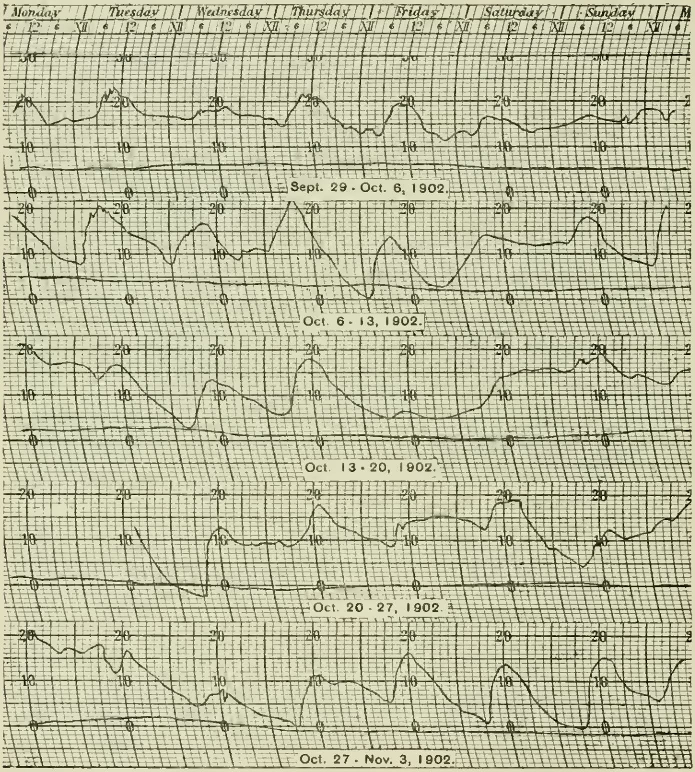

FIG. 6.—Tracings of thermographic curves of the air, and of the soil at a depth of 30 centimeters (1 foot), September 29–November 3, 1902. A further drop in temperature is shown which carries the soil below the freezing point temporarily on the 22d, and finally for the season on the 29th. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

During the movement of the water from the roots to the leaves of grasses and other low growing plants, a total distance of no more than 50 centimeters (20 inches) may be traversed, occupying a matter of a few minutes, or an hour at most, during which time the temperature is raised the above amount. The warming of the liquid as it passes upward through the living and nonliving cells is attended by alterations in its solubility of mineral and organic substances and by a decreased capacity for holding gases in solution. The downward movement of solutions of sugars, acids, and nitrogenous

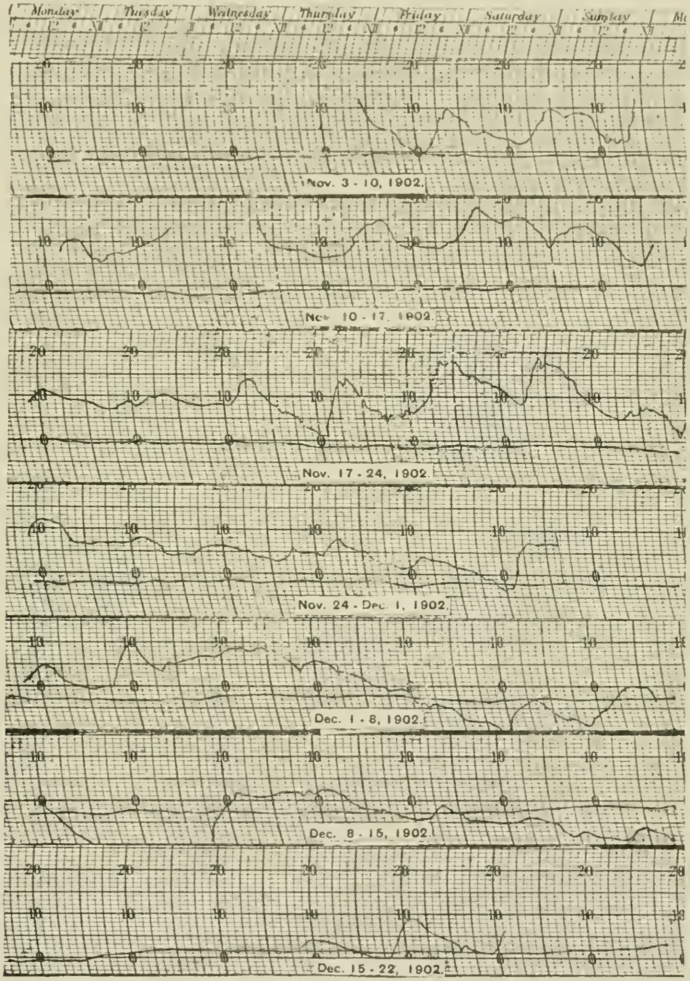

FIG. 7.—Tracings of thermographic curves of air, and of the soil at a depth of 30 centimeters (1 foot), November 3–December 15, 1902. The soil remained below the freezing point until December 8, when it began to rise steadily, and did not fall below freezing point during the remainder of the winter. Centigrade scale. The temperature of the air is shown by the uppermost of each pair of tracings.

substances from the leaves encounters the opposite set of conditions. This movement takes place almost entirely by osmose and diffusion and is a much more complicated process, both chemically and physically, taking place in living cells only. The cooling of the liquid would entail alterations in its power of carrying substances in solution and would also alter its physical relations to the atmospheric gases present.

It may be said, in conclusion, that the facts disclosed as to the actual temperatures in the soil, the diurnal and seasonal changes therein, and as to the differences in temperature of the aerial and underground portions of plants can not fail to be of very great importance in the physical and chemical processes, upon which growth, cell division, nutrition, and propagation depend. The determination of the effect of differences in temperature between the roots and aerial shoots has received but little consideration from the physiologist and the geographer. A careful analysis of the conditions and results of experimental observations carried on with plants under artificial conditions, with the roots and shoots under abnormally similar temperatures, would no doubt result in the detection of many mistaken conclusions, especially in regard to absorption, translocation, and transpiration.

That soil temperatures and the relations of these temperatures to those of the air must be of very great importance in the cultivation of economic plants is self-evident, especially in species in which the desired useful portion is formed underground and receives storage material formed by the activity of the aerial organs. Thus, in the case of such plants as the potato, certain mineral substances are absorbed from the soil at a comparatively low temperature, carried aloft into the heated leaves, where they participate in activities resulting in the formation of sugars, starches, and other carbohydrates, perhaps some nitrogenous substances as well, and then these complex bodies are slowly diffused downward, with many accompanying chemical and physical modifications, to underground cool storage organs, where a condensation occurs and the products are stored in insoluble form in the tuber.

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CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN--No. 45

STUDIES IN PLANT HYBRIDS: THE SPERMATOGENESIS OF HYBRID PEAS

By WILLIAM AUSTIN CANNON

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Studies in Plant Hybrids: The Spermatogenesis of Hybrid Peas*

By William Austin Cannon

(With Plates 17–19)

Up to the present the studies on the origin and development of the spores and sex-cells of hybrids have been made with no definite knowledge of the manner of the variation of the hybrid race and without regard to or accurate knowledge of the degree of fertility or sterility of the forms, and it seems almost unnecessary to remark that no study can be at all complete, whatever its results or conclusions may be, that does not take into consideration each of these conditions.

Studies on the sporogenesis and spermatogenesis of hybrids include the researches on cannas by Guyer,† on cotton by Cannon, on *Drosera* by Rosenberg, on *Gladiolus* by Metcalf, on pigeons by Guyer and on *Syringa* by Juel. Nothing definite is known, so far as I am aware, about the variation of any of these hybrids, and as regards their fertility probably not one is entirely fertile, and *Syringa* at least is thought to be quite sterile.

There are two or three conditions at least to which a hybrid plant should conform in order to be well adapted for study from a morphological standpoint. These are briefly: the hybrid must be fertile; it must vary in a definite and known manner; and, finally, it must be suitable in itself, as distinguished from all other requirements, for histological study.

One reason why the pea hybrids are so well adapted to experimental researches is that they are fertile. This, indeed, was one of the reasons that led Mendel to select them for his studies. I

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* This study was made with the aid of Grant No. 27 of the Carnegie Institution.

† See bibliography at the end of this paper.

have observed also that the peas used in the present study were fertile; they produced pods which were usually well filled with seeds capable of germination. These observations are in harmony with the manner of the formation of the spores; no irregularities whatever, which in any way were traceable to the plants as hybrid organisms, were seen. If these observations are correct, the conclusion can hardly be avoided that the variations and reversions of hybrid peas are associated with normal processes, such as are found in the pure types, and hence that abnormalities are merely indications of the hybrid nature of the forms that bear them, although by no means diagnostic characters. It is then a question fairly open for the cytologist to determine, what the nature of those processes are, and this has yet to be done.

The hybrids used in this study, * Fillbasket × Debarbieux and Express × Serpette, showed variation after the law of Mendel, although I should state that they were not examined more than was necessary to surely establish this point. The seeds from which the plants studied were derived were from those of the first generation. The Fillbasket × Debarbieux seeds were yellow and green, nearly in the ratio 3 : 1. Of course most of the flower-buds were removed for study, but in a few cases I left the flowers to fertilize themselves. The plants which came from the green seeds bore green seeds only, and those from the yellow seeds bore seeds that were both yellow and green in the ratio 3 : 1. In the crosses in which Serpette was used as one of the parents, as for example Express × Serpette, the Serpette dwarf character was noticed in the offspring as presumably the recessive one; it appeared in at least one third to one half the total number of third-generation plants. In Express × Serpette there were seventy-two plants which resembled the Express ancestor, and thirty which were dwarfed and which were like the Serpette race. The illustrations (*f. 34–37*) show fairly well the appearance of these reversionary types and the pure forms also.

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* I am indebted to Professor William Bateson for the seed from which the hybrids were raised. Professor Bateson very generously sent me some first crosses, several of the second generation and also the pure types.

I wish also to acknowledge the assistance of Mr. Homer D. House, of Columbia University, for aid in preparing material for study, and that of Miss Palmyre de C. Clarke, of the New York Botanical Garden, who prepared the bibliography.

FILLBASKET AND DEBARBIEUX, PURE RACES

No difference in the origin and development of the microspore was noted between the pure races Fillbasket and Debarbieux. In both the reduced number of chromosomes was seen to be the same, namely seven, and the chromosomes appeared to be quite alike in each ; to avoid repetition the general account of the maturation processes will be deferred until the next topic. Favorable material, however, gave opportunity to observe the sporogenous divisions in Fillbasket and the results are here presented.

In the most of the sporogenous divisions the mitotic figures are likely the same as in the somatic nuclei ; but in late anaphases or early telophases certain characters were seen which were apparently somewhat different. In early telophase of one of the later sporogenous divisions the chromosomes are associated in pairs, touching by one, the polar, end. A nucleus with such chromosomes is shown in *f. 4*. This division was evidently the last sporogenous one, that is, the nucleus figured would become that of the spore mother-cell without further division. Whether the chromosomes are ever in touch throughout their whole length, as appears to ocbur in Fillbasket × Debarbieux (*f. 6*), was not determined. The later history of the chromosomes is of great interest, since upon a proper understanding of it may depend an appreciation of the significance of the loops of chromatin which appear subsequently in the nucleus as one of the prophases of the first maturation division. If, as supposed, the spireme of the nucleus of the spore mother-cell is double, we might look for a previous doubling of the chromosomes, although this might perhaps not follow. I have seen no clear indication that the chromosomes form a double spireme in the telophases of the last sporogenous division. The behavior of the chromosomes at this time is as follows : As they approach the poles of the spindle they are appreciably more uniformly arranged and more nearly parallel to the long diameter of the spindle than in the other divisions in the sporogenous cells, when at the poles the chromosomes unite or touch two and two by the polar ends. In this condition they enter the resting stage ; a continuous spireme was not seen. In some nuclei the adjoining pairs of chromosomes were apparently united by their free ends, but I did not surely determine this point. If the chromosome pairs are united in this manner a continuous spireme of single chromosomes united end to end would be the result. The results of my observations upon this point were somewhat contradictory, and this may have been owing to the possibility that not all of the nuclei studied were undergoing the last sporogenous division, and that the pairing of the chromosomes and the form of telophase following are, in the pea, peculiar to the presynaptic nuclear division. I hope at another time to give a more complete account of this division.

When I observed the association of chromosomes as above described I supposed that it was merely from chance, which indeed may yet prove to be the case, and not the usual and normal occurrence in such cells, because it surely is not at all likely that so noticeable a thing could for any length of time escape the eyes of trained cytologists. The better to reinforce the correctness of my observation, or to prove it false as the case might be, I studied the mitoses in the nuclei of somatic cells. As a rule, there is no indication whatever in the somatic nuclei of peas of the association of the chromosomes in twos, but in one nucleus an appearance recalling the pairing was observed. In this case a closer examination showed that the association did not include all of the chromosomes and was very evidently one of chance merely; so that it seems to me that the association of the chromosomes in pairs in the last sporogenous division in Fillbasket does not find a counterpart in any somatic cells and is not the result of chance.

FILLBASKET × DEBARBIEUX

In studying the sporogeny of the hybrid Fillbasket × Debarbieux my aim has been rather to notice departures from the "normal," and by it to discover if possible the structural causes of the remarkable "splitting" of the Mendelian hybrids, than to examine critically and minutely the several nuclear divisions for themselves. Accordingly I have observed the behavior of the chromosomes more especially in the two maturation mitoses, in the first division of the microspore and in the last division of the sporogenous cells.

The sporogenous cells of the hybrids were rather easily distinguished even in young anthers because of their position and by the greater density of the cytoplasm, although it should be said that it is not seldom difficult surely to determine the character of a given cell. To study the divisions from which the sporiferous tissue arises it is necessary to obtain very young anthers indeed, those which are merely slight protuberances on the primordium of the flower. The difficulties in the way of studying the anther are decidedly increased from the fact that the inflorescence consists of not more than four or five flowers, all usually in widely different stages of development.

For the most part the nuclear divisions in the sporogenous cells of Fillbasket × Debarbieux are of the regular equational type, quite the same as those in the somatic cells of the plant. That is, fourteen segments are formed in the prophases and these become arranged in the equatorial plate and in metaphase are already split before the migration to the poles of the spindle. In anaphases the chromosomes are frequently L-shaped, although not so sharply bent, and are arranged haphazard, that is, as purely by chance. In the telophases the chromosomes unite end to end and form a spireme; this becomes changed into a delicate reticulum in which all trace of the chromosomes as such disappears.

In some of the later sporogenous divisions a departure from the usual appearance was noted as in the case of the pure form Fillbasket. In Fillbasket × Debarbieux the same curious association of chromosomes two and two was observed in a few cases. *F. 6* shows an anaphase of the last sporogenous division; the pairing was even more clearly marked in the preparation than in the sketch. The pairing was with a single exception observed in anaphase or early telophase only. The exception is shown by *f. 5*, which is an equatorial plate in probably the last division before synapsis. I have not seen the association in early anaphase for the reason perhaps that the chromosomes are at that time under the influence of the spindle fibers.

When the chromosomes reach the poles of the spindle they unite by their polar ends, and these appear to fuse together, making a more or less well-marked ring from which depend the chromosomes in pairs. This is shown very imperfectly by *f. 7, 8* and *9*. In no case did I see a spireme which I could surely say was continuous or which was made up of more than two elements; this may well be because the particular stage was wanting in the preparation. On the other hand instances were observed, like *f. 8*, in which a reticulum was being formed from the condition as just described. The exact fate of the chromatin was thus not determined.

The association of chromosomes in pairs in the early history of the reproductive cells recalls the similar condition in animals as given by Montgomery * and Sutton.† But the significance of the association in hybrids is not entirely clear, since with Montgomery's hypothesis in mind that in pure races the two chromosomes of each pair are of different parentage, it seems difficult to conceive of Sutton's as applied to hybrids, that the members of each pair cover the same field of development; because in hybrids the latter can only be true in a broad way, depending apparently upon the affinities of the pure parents of the form. It may be, however, that the differences between the chromosomes of any pair in hybrids capable of forming functional spores are so slight that union is possible even if the potentials of the chromosomes are not identical.

After the sporogenous cells are cut off there ensues a long period of growth during which the nucleus of the young spore mother-cell undergoes characteristic changes. The chromatin of the nuclear reticulum becomes gathered to one side of the nucleus and the contracted condition known as synapsis results. The preparation for synapsis takes place at an early time in the history of the spore mother-cell, and the portions of the nuclear changes resulting in synapsis which were seen may be briefly described. The delicate reticulum which extends through the nuclear vacuole of the resting nucleus becomes so changed that small masses of chromatin of unequal form and size are found scattered along its meshes, more especially in the peripheral part of the nucleus. These masses are arranged in lines which often radiate from the nucleolus as a center; the linin threads which connect the masses may be seen for a considerable distance from them extending into the nuclear vacuole. From a position extending over the entire periphery of the nucleus the chromatin becomes gathered to one side of the vacuole; when it enters into the synapsis stage it is probably already in the form of a continuous spireme. It is much bent with short turns and appears usually to be homogeneous and not split; the spireme at this time closely resembles the much convoluted thread with its short, sharp turns as it emerges from the synapsis stage. Since the chromatin assembles in a spireme before the so-called synapsis condition the significance of the latter is not apparent in these forms.

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* Montgomery, T. H. The heterotypic maturation mitosis in Amphibia and its general significance. Biol. Bull. 4: 259. 1903.

† Sutton, W. S. On the morphology of the chromosome group in *Brachystola magna*. Biol. Bull. 4: 24. 1902.

The cytoplasm of the spore mother-cell is reticular and it always, from the spore mother-cell to the tetrad, retains this structure. In this regard the pea is very different from the cotton hybrid in which kinoplasm forms a marked character of the cytoplasm in the more advanced stages of spore formation, and from some of the homologous cells of *Syringa Rothomagensis* * in which kinoplasm is strongly developed. The exaggerated development of kinoplasm or filar-plasm in the cytoplasm of the spore mother-cells is therefore not a constant or diagnostic feature of hybrids.

Although I did not study closely the origin of the achromatic figure, I observed that it is derived from a multipolar one. The multipolar spindle originates in groups of fibers which are placed near the outer edge of the cytoplasm and which radiate from a common point towards the nucleus. The place of genesis of the achromatic figure is therefore very different from that of the cotton hybrid, and the structural reason appears to lie in the presence in the latter, and absence in the former, of a dense perinuclear zone of cytoplasm. The achromatic figure in cotton originates inside of this perinuclear zone, which thus appears to inhibit its more peripheral origin. It may also be that the zone of denser cytoplasm which in the cotton closely surrounded the nucleus not only formed a limiting boundary for the spindle, but at the same time made necessary for the mechanical support of the cell the formation of an outer layer of kinoplasm, and that its absence in the pea not only changed the structural relations of the parts of the cell but altered the mechanical condition as well, making the formation of the kinoplasmic layer unnecessary.

The first maturation mitosis is heterotypic. The chromosomes in the metaphase are not different from those in the pure races Fillbasket and Debarbieux. Their relatively large size and small number make the observation of them comparatively easy and sure. The reduced number is seven; this number was repeatedly seen in the first division and was verified in the second mitosis and in that of the division of the nucleus of the tetrad also.

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* Juel, H. O. See bibliography.

The chromosomes in the anaphases of this division are more or less bent and some show the splitting sometimes seen in these stages of division. There was an equal apportionment of the chromosomes, both as regards their number and size, to the daughter nuclei. The single exception to this, and the only abnormality noticed in the hybrids, is shown in *f. 23*. In the nucleus from which the sketch was made one chromosome lagged behind its companions; fission, also, had not taken place.

The daughter nuclei undergo reconstruction to a greater degree than was observed in the cotton hybrid, but on account of the small size of the nuclei the study of them is difficult and unsatisfactory. The chromosomes in early telophase are much elongated and appear to unite end to end to form a single spireme, which later becomes lumpy and more or less reticular. The identity of the chromosomes is quite lost.

In the prophases of the second division a spireme, which does not seem to be split, may be seen, and the chromosomes formed from it become associated in pairs in the nuclear plate, but they may not on that account, as Mottier shows, be sister chromosomes. It is probable, however, that they are, and that they are not homologous with the pairs found in the presynaptic division. The metaphase or the anaphases present no noteworthy condition. The reduced number of chromosomes, seven, was frequently observed and the number verified.

In late anaphases of the second division the cell-plates separating the daughter nuclei may be seen, and when the granddaughter nuclei are reconstructed cell-division occurs. Immediately after the division of the cell the tetrads are angular in form, but they soon become spherical and at length they assume the elliptical form characteristic of the pollen-grain. During these changes in form the tetrad increases much in size and the nucleus of the young spore moves from its early central position to one end of the cell and there prepares for the division of the nucleus of the microspore.

The first division of the nucleus of the spore (*f. 32*) appears to be similar to that of the somatic nuclei except for the number of the chromosomes and the shape of the spindle. The chromosomes are of course the reduced number, and the spindle, owing perhaps to the eccentric position of the nucleus, is somewhat truncated. As in the two preceding divisions, the distribution of the chromosomes in this one was apparently perfectly equable. Therefore in all and in each of the nuclear divisions which were directly connected with the development of the microspores the number of the chromosomes, and also presumably the amount of chromatin, were equally distributed.

In late anaphase of the first division of the nucleus of the microspore a cell-plate is seen separating the crescentic-shaped generative nucleus from the vegetative one. Reconstruction of the two nuclei goes on at an unequal rate. The vegetative appears always to form its wall in advance of the sister nucleus, and its chromosomes are also the first to become reticulated and lose their identity. In the reconstruction of both nuclei excellent opportunity was given to observe the beginning and extension of the nuclear wall, which appear to occur precisely as Lawson has described.*

SERPETTE, PURE RACE.

The material of the pure parents of the Express × Serpette hybrid at my disposal was not sufficient to permit an extended study of either; but some observations were made on the critical stages of spore-formation in Serpette.

The first maturation division in Serpette is heterotypic and the second homotypic. In the anaphases of the first division the chromosomes were not seen to be split, either for part or all of their length, as was the case in the other pure races and the hybrids also. In the telophases of the daughter nuclei the chromosomes unite end to end and form a continuous daughter spireme. In both maturation mitoses the reduced number of chromosomes was seven. No differences in form or size were noticed between the chromosomes of this and those of the other pure races.

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* Lawson, A. A. On the relationship of the nuclear membrane to the protoplast. Bot. Gaz. 35: 305. 1903.

EXPRESS × SERPETTE

Like Fillbasket × Debarbieux, this is a second generation hybrid, and it also, as has been described in a preceding paragraph, shows the splitting into several types after the law of Mendel. The reversion of Express × Serpette as regards the quality of size and form of the plants is fairly well indicated by *f. 34–37*, where the pure parents are also represented. It should be noted that the sketches are drawings from photographs and that the plants were photographed at the same time and under precisely the same conditions, so that the figures faithfully reproduce the relative forms and sizes of all of the plants.

The sporogeny of Express × Serpette corresponds closely in the points examined to that of Fillbasket × Debarbieux, although in certain regards, which will be indicated, a difference between the two was noted. Also some phases of development were represented in my preparations of Express × Serpette, not found in those of the other hybrid, and these will be mentioned, in addition to the preceding, rather than a more complete account. By this method I shall avoid unnecessary duplication; the two hybrids are so nearly alike in the matter of spore origin and development that a description of these processes in the one would for the most part answer perfectly well for the other.

The series representing the nuclear divisions in young anthers was not so complete in Express × Serpette as in Fillbasket × Debarbieux, and possibly for this reason I have not so complete evidence of the association of the chromosomes in pairs in the last sporogenous division in the former as in the latter hybrid. It was observed, however. An apparently good example of the pairing was seen where perhaps one would not expect it, namely, in the division by which the sporangial wall is separated from the inner sporiferous tissue. The outer cell resulting from this division by further division gives rise to three series of cells, the inner of which forms the tapetum; the inner cell of the division noted becomes converted without further division into a spore mother-cell. The division referred to occurs rather late in the pea. Both of the nuclei resulting from this division had their chromosomes arranged in twos. If the curious association of the chromosomes is an especial preparation for synapsis, the condition of the outer one is surely paradoxical.

The nucleus of the spore mother-cell enters into a complete resting condition in which it remains during much or most of the period of growth of the cell. As a preparation for synapsis the chromatin of the recticulum collects into masses of irregular shape and size, more or less arranged in threads, about the periphery of the nuclear vacuole. The chromatin-thread at length takes up a position around or closely applied to the nucleolus and the synapsis stage results. When the mass of chromatin unloosens, it is seen to be made up of a much bent ribbon. The spireme is at first beaded in appearance, but it becomes more regular in outline and also increases in its capacity for absorbing stains. The splitting of the spireme was not clearly seen, although evidences of it were noticed. In a few cells I saw the chromatin-loops which are characteristic of the prophases of the first maturation mitosis (*f. 15–17*), but in each case the loop was not contracted and did not show the second fission which was observed in the cotton hybrid.

The two maturation divisions were quite like those seen in Serpette and in Fillbasket × Debarbieux. The reduced number of chromosomes was seven.

A difference in the origin of the multipolar spindle of the first mitosis of Express × Serpette from that of Fillbasket × Debarbieux was noted (this stage was not seen in Serpette), but whether it was an artefact or not I was unable, because of the lack of material, definitely to determine. In several spore mother-cells the cytoplasm was very dense in the immediate neighborhood of the nucleus, forming what was in effect a perinuclear zone. In these cells the multipolar spindle seemed to have its origin wholly within the nucleus. The linin became lumpy and very distinct, it formed a mesh-work which gave the appearance of polarity, and had every indication of being the genesis of the multipolar spindle. The nuclear wall remained in some cases recognizable even when the intranuclear material was of a pronounced fibrous character. The departure from the extranuclear origin of the spindle observed in Fillbasket × Debarbieux is certainly a marked one, and interesting even if it proves in the end to be an artefact.

SUMMARY

The main points in this paper may be briefly stated as follows:

1. Both of the hybrids studied and reported on in this paper, Fillbasket × Debarbieux and Express × Serpette, were of the second generation, that is, their grandparents were pure races of peas; both of the hybrids exhibited variation after the Mendelian law.
2. The hybrids are fertile.
3. Both of the hybrids matured their spores quite as the pure ancestral forms did. The first maturation mitosis was heterotypic, the second homotypic.
4. The reduced number of chromosomes is seven, the somatic number fourteen.
5. No abnormal mitoses were observed.
6. In the anaphases of the last sporogenous division of both hybrids, and of the pure form Fillbasket, the chromosomes were associated in pairs; this condition was seen also in one nucleus of Fillbasket × Debarbieux that was in the nuclear plate stage. The paired condition is probably not the result of chance; further work, however, which the writer hopes to carry on, will be necessary definitely to determine this point.

CONCLUSIONS

If the physical basis for the Mendelian variation of hybrid peas was not demonstrated by a single histological study of them, certain conclusions which touch more or less directly the causes of the variation may nevertheless be legitimately although tentatively drawn. In the first place it has been shown that the variation of the peas, in the third generation at least, is due entirely to the union of gametes which originate and develop quite the same as do those of the pure ancestral types, or in other words, abnormalties and irregularities of nuclear divisions do not form the basis for the variation of these hybrids.

What then is the probable structural basis for the Mendelian variation of the hybrid peas? As has already been intimated, I think it is fairly well shown that this basis is the same as that of the variations in the pure forms, and if so an understanding of the latter should give the key to explain the former as well. But nothing is clearer than the fact that the present conception of the essential nature of the maturation processes in pure races of plants does not provide adequate grounds for this variation. This study will hardly profess to do this, but I may repeat what I have before suggested * and what Montgomery † and Sutton ‡ have emphasized, that a study of the early history of the reproductive cells may give some clue leading to a better understanding of the meaning of heterokinesis, and, at the same time, a truer conception of the physical basis for variations, both in pure races and in hybrids. With this idea in mind I have studied, as well as the material at hand would permit, the divisions of the sporogenous cells, more especially the last one, the division preceding the first maturation mitosis, in the hybrids and in the pure form Fillbasket, and I have found unmistakable evidence of an association of the chromosomes two and two. Of course I cannot say positively that this was not a chance association, since I could not trace the later phases of these divisions as closely as would have been desirable, but the pairing was observed in well prepared material and had every appearance of being the normal and regular occurrence. If further studies confirm this observation, it may prove of great importance in explaining the structure of the heterotype rings. There are difficulties in the way of positively identifying any chromatin loop as having its origin in any given pair of chromosomes, because the nucleus enters on a complete resting stage at the close of the presynaptic mitosis and the identity of the chromosomes is lost. Further studies may, however, give results that point to a connection between the two even if they do not make the demonstration. For example, I have seen the union of chromosomes by the polar ends only, in the telophases of the last sporogenous division, and I failed to find, although I searched very closely, the formation of a spireme, but in the place of it the *pairs* of chromosomes appeared to be united at the polar ends. A continuous spireme may not be formed in this division. It is conceivable therefore that the chromosome pairs which enter the resting condition may be identical pair for pair with the loops which are formed later.

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* Cannon, 2.

† Montgomery, *l. c.*

‡ Sutton, *l. c.*

Mottier * has described processes in the second maturation division which should be considered in connection with the earlier nuclear divisions as well. In the metaphase of the second division the chromosomes are brought into the paired position in the nuclear plate by the action of the fibers of the spindle; that is, the pairing here is probably due to the activity of the achromatic elements. This seems to make unnecessary the conception of the preliminary pairing of the chromosomes as a direct preparation for heterokinesis, since the spindle can distribute the chromosomes at its will, so to speak. It should be considered, however, that the rings are bivalent, and are probably formed without the intervention of the fibers, since the rings antedate the formation of the spindle itself. Also, if my observation is correct, the spindle fibers are not instrumental in segregating the chromosomes in the presynaptic division, because in that case, with possibly one exception, the pairing was not observed until the chromosomes were at the poles of the spindle and hence probably after the work of the fibers of that dividing nucleus was done. So it may well be that there is not only a difference in the homologies of the chromosome-pairs of the metaphase of the second division and those of the presynaptic one, but a difference in their affinities as well; consequently influences, whatever they may be, other than those of the spindle, may cause the earlier pairing.

The foregoing considerations are based upon the idea of the individuality of the chromosomes and upon that of their being qualitatively unlike.† If these conceptions are valid we should

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* Mottier, D. M. The behavior of the chromosomes in the spore mother-cells of higher plants, etc. Bot. Gaz. 35: 250. 1903.

† The results of Rosenberg's studies (see bibliography) on the sporogenesis of the natural hybrid between *Drosera longifolia* and *Drosera rotundifolia* seem to throw objections in the way of too strict a conception of the individuality of chromosomes in hybrid plants. Rosenberg finds that the reduced number of chromosomes in the *Drosera* hybrid may be 10, as in *D. rotundifolia*, or 20, as in *D. longifolia*, or 15, which is half the somatic number in the hybrid. He also finds some evidence indicating that part of the chromosomes may be made up of four portions of chromosomes each, and others of two halves of chromosomes each; the former kind are also larger. In any case it is difficult to reconcile Rosenberg's results with the idea that the chromosomes are distinct morphological entities; the results point rather to the preservation by a portion of the spores of the purity of the chromatin, a fact which may prove disconcerting to recent critics in this field (Cook; see bibliography). It should be

have spores which might be of pure descent or might not be so according to the manner of the orientation of the segments in the metaphase of the first division. The chromosomes might be associated and distributed by chance as I have recognized (Cannon, 1) and as Sutton has dwelt on at length.* What the connection of the chance distribution of the chromosomes may be with the distribution of the characters among the hybrids is not at all clear, since the relation of the chromosomes to the characters is not known, but the cytologist has abiding faith that there is some connection which will be demonstrable with the microscope, and he looks to the field of hybrids and of hybridization as a new opportunity for experimentation by which to supplement and to substantiate the results of his studies. Experimentation and cytological studies on hybrid forms in which the number of chromosomes is known and in which the number of characters has been determined should show a connection, if there is one, between the number of characters that are transmissible and the number of the chromosomes and their morphology. I wish here to call attention to what very likely is merely a chance coincidence, but nevertheless suggestive and interesting, namely, to the agreement in the number of the groups of constant differentiating characters as given by Mendel for the peas used by him in experiments with the reduced number of chromosomes in the peas. As given by Bateson (Bateson, 1), the characters are (*a*) differences in the length and color of the stem; (*b*) in the size and form of the leaves; (*c*) in the position, color and size of the flowers; (*d*) in the length of the flower-stalk; (*e*) in the color, form and size of the pods; (*f*) in the form and size of the seeds; (*g*) in the color of the seed-coats and cotyledons. In the peas there are evidently more appreciable characters than chromosomes, and therefore the chromosomes bear more than one character each. If then the chromosomes maintain their individuality certain characters might be associated together in the same chromosome, and might be

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borne in mind, however, that a difficulty in drawing conclusions at present from the results of Rosenberg's studies of the sporogeny of the *Drosera* hybrid may lie in the partial sterility of the form. (See Focke, Pflanzenmischlinge, 155.) Further work on this hybrid is promised and will be awaited with interest.

* Sutton, W. S. The chromosomes in heredity. Biol. Bull. 4: 231. 1903.

coupled together in the hybrid organism, not being capable of separating from each other — correlations are not unknown among hybrids. The idea suggests itself that the case might be very different if the number of the chromosomes in relation to that of the characters were greater than in the pea ; the chance association and distribution of chromosomes representing portions of characters might not bring about so evident a distribution of characters in the hybrid generations, the Mendelian reversions. May it not be possible then that fortune favored Mendel when he selected for his experimentation plants which had so small a number of chromosomes ? *

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List of the More Important Recent Works on Plant Hybrids

Abbado, M. L'ibridismo nei vegetali. Nuovo Giorn. Bot. Ital. II. 5 : 76, 265. 1898.

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* The data at hand showing the number of chromosomes in the somatic cells of Mendelian hybrids are unfortunately not complete. According to Wilson (The Cell, 206), in wheat there are 16 chromosomes, and in cattle and rats the number is probably the same ; the mouse has 24 chromosomes ; according to the present study the pea has 14. On the other hand, there are 56 chromosomes in the somatic nuclei of hybrid cotton, but the nature of the variations in the cotton, whether or not Mendelian, has not, I believe, been determined.

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Explanation of Plates

Note.—A Zeiss microscope with a 2.00 mm. homogeneous oil-immersion objective and a number 18 eye-piece were used, together with a camera lucida, in making all of the sketches in plates 17 and 18.

PLATE 17

FIGS. 1–3. Fillbasket, pure race. Anaphase of last sporogenous division; pairing of the chromosomes not well marked. The three sketches were made from one nucleus.

FIG. 4. Fillbasket, pure race. Late anaphase of the last sporogenous division. The chromosomes are uniting in pairs. One chromosome is in the section next to the one from which the sketch was made.

FIG. 5. Fillbasket × Debarbieux. Nuclear plate of the last sporogenous division. Six chromosomes are associated in pairs.

FIG. 6. Fillbasket × Debarbieux. Anaphase of last sporogenous division showing a pairing of the chromosomes.

FIG. 7. Fillbasket × Debarbieux. Early reconstruction stage in last sporogenous division, showing the fusing of the pairs of chromosomes at their polar ends; three chromosomes are in the adjoining section. The connecting chromatin is exaggerated in the sketch.

FIG. 8. Fillbasket × Debarbieux. Same division as the preceding; the connecting ring of chromatin does not become reticulated as early as the remainder of the chromosomes.

FIG. 9. Fillbasket × Debarbieux. Same division as the preceding sketch; shows fusing of chromosomes at the polar ends.

FIGS. 10–14. Fillbasket × Debarbieux. Figs. 10–12 are sketches of metaphase of sporogenous division, *probably not the last one*, and figs. 13 and 14 are anaphases of two similar divisions. These do not show pairing of the chromosomes.

PLATE 18

FIGS. 15–17. Express × Serpette. Prophase of the first maturation mitosis, heterotype rings.

FIGS. 18, 19. Fillbasket × Debarbieux. Metaphase of the first maturation division.

FIG. 20. Fillbasket × Debarbieux. Chromosomes from the metaphase of the first division.

FIG. 21. Fillbasket × Debarbieux. Nuclear plate, first division, showing the reduced number, seven, of chromosomes.

FIGS. 22, 23. Fillbasket × Debarbieux. Anaphase of the first maturation mitosis; in the latter sketch one of the chromosomes has failed to divide; this was the only abnormality which was seen in the sporogeny of the pea hybrids.

FIGS. 24, 25. Fillbasket × Debarbieux. All of the chromosomes of one daughter nucleus are shown; the number of chromosomes is seven.

FIG. 26. Fillbasket × Debarbieux. Early reconstruction stage of a daughter nucleus; one chromosome is in the adjoining section. No splitting of the segments is to be seen.

FIG. 27. Fillbasket × Debarbieux. Metaphase of the second maturation division.

FIG. 28. Fillbasket × Debarbieux. Typical chromosomes from the metaphase of the second division.

FIGS. 29, 30. Fillbasket × Debarbieux. Metaphase of the second division showing the reduced number of chromosomes to be even; the nuclei are sister nuclei.

FIG. 31. Fillbasket × Debarbieux. Resting nucleus of tetrad; shows complete resting condition.

FIG. 32. Fillbasket × Debarbieux. Metaphase of the first nuclear division of tetrad; germination of microspore.

FIG. 33. Fillbasket × Debarbieux. Reconstruction of the vegetative and the generative nuclei in first mitosis of tetrad nucleus.

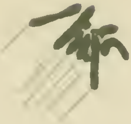
PLATE 19

FIG. 34. Express, pure race. (Reduced.)

FIG. 35. Serpette, pure race. (Reduced.)

FIG. 36. Express × Serpette, showing Express reversion. (Reduced.)

FIG. 37. Express × Serpette, showing Serpette reversion. Both of the figures of Express × Serpette were drawn from plants selected at random. They are representative second generation forms. (Reduced.)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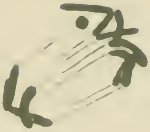
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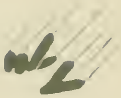
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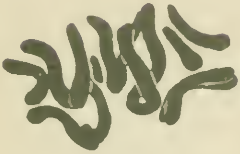
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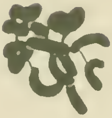
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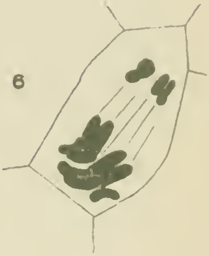
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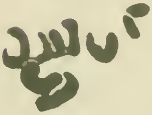
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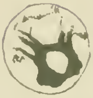
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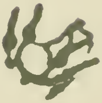
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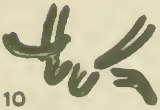
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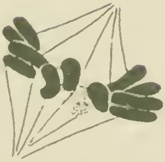
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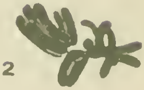
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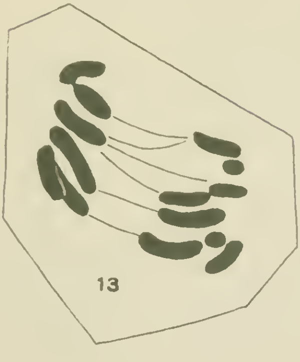
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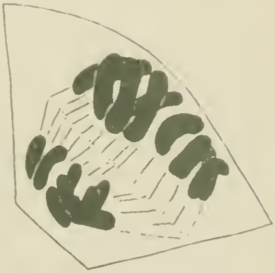
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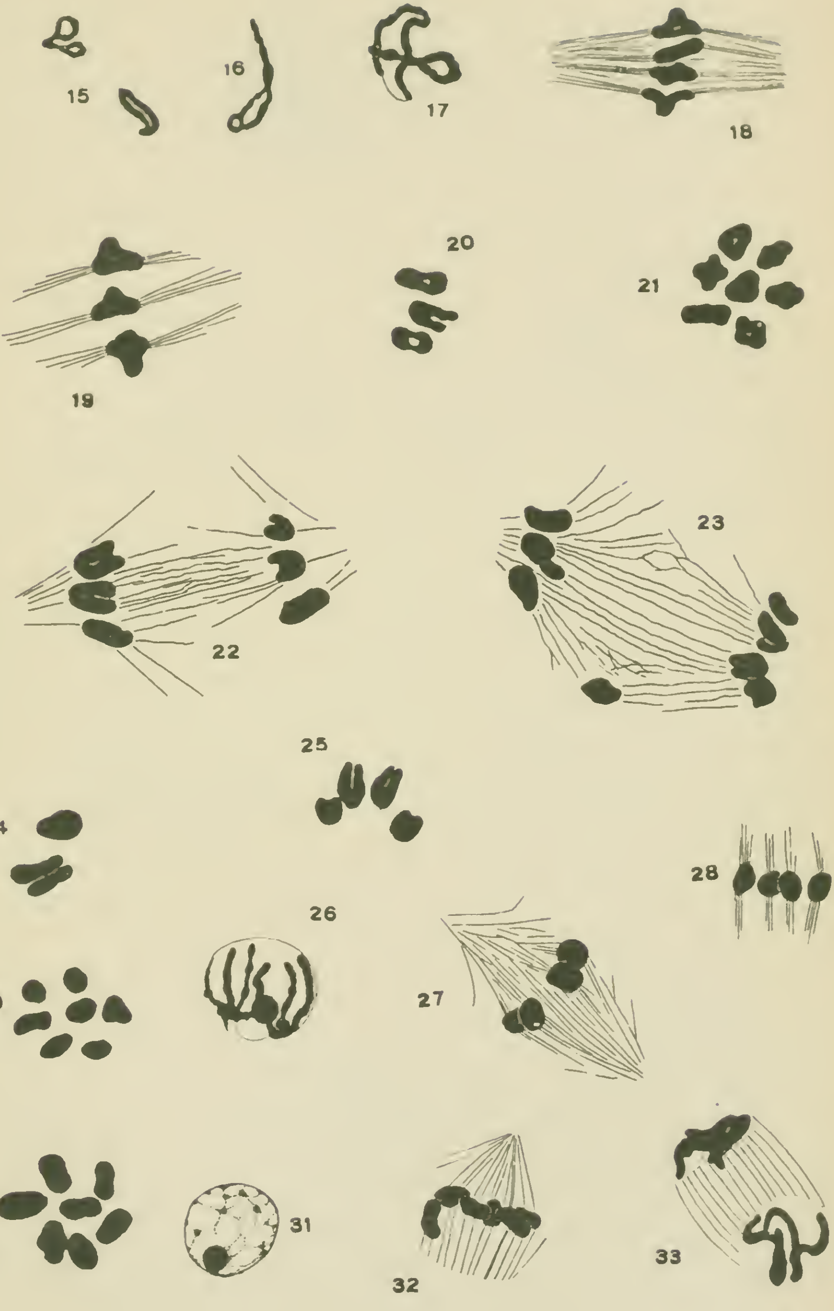
SPERMATOGENESIS OF HYBRID PEAS.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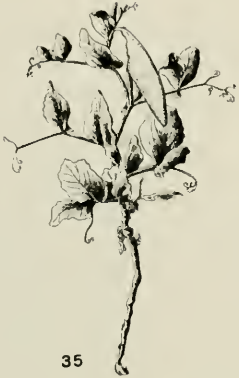
SPERMATOGENESIS OF HYBRID PEAS.



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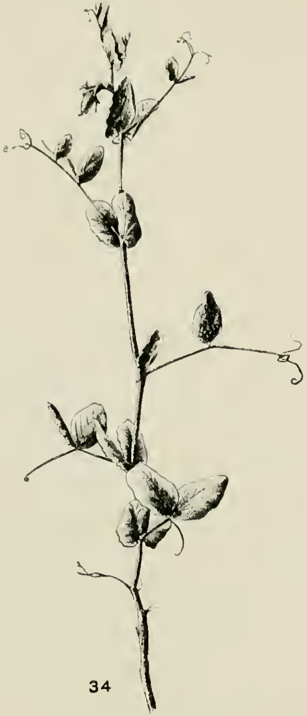

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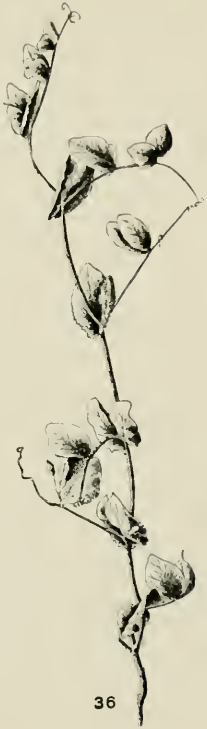

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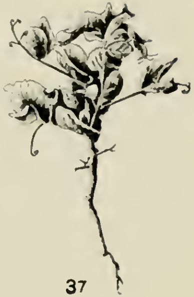

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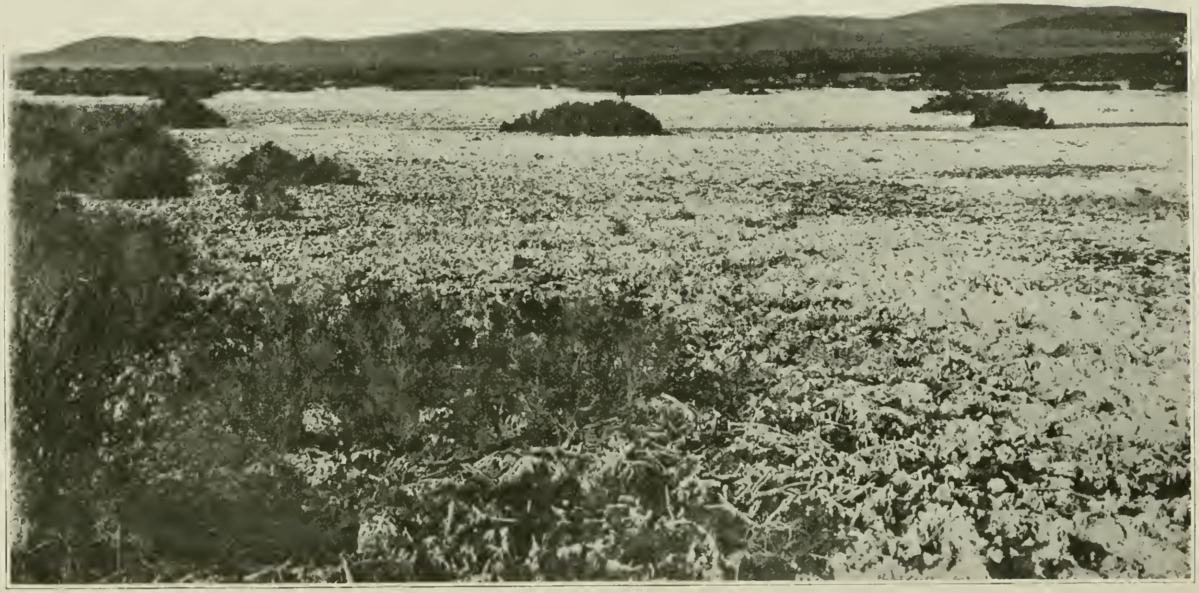
STUDIES IN PLANT HYBRIDS: HYBRID PEAS



MacDougal on Desert Vegetation. A scene in the Salton Basin, Colorado Desert. The white heavy saline incrustation is shown, and the vegetation, composed principally of *Allenrolfea*, is seen to occur in scattered clumps.
By permission, Desert Botanical Laboratory, Carnegie Institution.

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Some Aspects of Desert Vegetation.

BY D. T. MACDOUGAL.

A SERIOUS investigation of some of the numerous problems presented by the xerophytic vegetation of arid regions has recently been made possible by the establishment of the Desert Botanical Laboratory of the Carnegie Institution, which has been located at Tucson, Arizona. While any of the more important phases of botany might be the subject of investigation by means of the facilities offered by this laboratory, yet its special function consists of an inquiry into the morphology, physiology, habit and general life-history of the species indigenous to the deserts of North America, an area which amounts to more than a million square miles.

The conditions afforded vegetation in these districts show such wide departures from those of humid temperate, and those of tropical regions; the living flora is accessible to so few workers and the entailed investigations are necessarily so wide in scope, so extensive and difficult in execution, that the advance of knowledge of the life of desert plants has been comparatively slow. Nearly a decade has elapsed since any notable investigations have been made upon xerophytic vegetation as such, and in that period morphology and physiology have made a marked general advance, while heredity and the origin of species have taken on a renewed interest because of the results brought to light within the last few years. It may be expected therefore that a searching study of the vegetation of arid regions will afford information concerning the fundamental processes of plants that will materially modify some of the most important generalizations current in botany at the present time.

A brief sketch of investigations dealing with desert vegetation has recently been published in the report of the Advisory Board of the Desert Laboratory, together with a bibliographical appendix which includes the principal papers bearing upon the subject.*

It may be profitable to point out some of the striking features of the more prominent types of plants indigenous to arid regions, and to call attention to phases of their life-history needing investigation, at the outset of the activity of the Laboratory.

A general inspection of the southwestern deserts during the active vegetative season and during the resting period shows that the following groups of plants may be distinguished upon the basis of seasonal habit and general composition of the shoot and root. In citing these groups it is by no means intended that the divisions in question are to be taken to include the entire flora. The ideas set forth in this crude classification however may serve as a point of departure for an exhaustive analysis of the flora upon a more exact basis of habit and habitat:

I. Herbaceous annuals which start into activity from seeds soon after the beginning of the rainy or favorable season, and quickly develop a complete flowering shoot.—The formation of flowers and the maturation of seeds ensues under conditions not widely different from those encountered by species living in the same latitude in moister regions. The roots of such plants are not distinguishable by any special characteristics, and do not exhibit any unusual capacity for the penetration of the soil, horizontally or vertically. The greater number of forms of this group however show a comparatively greater development of the lateral roots through the upper layers of the soil in a manner that places these organs in a position to make use of the scant rainfall before it sinks deeply into the soil. The shoots do not present marked xerophytic adaptations beyond a heavy cuticle, and the usual regulatory devices for controlling the action of stomata. The total leaf surface of the shoot may be very great, and the whole plant so delicate that it quickly wilts when uprooted. The more marked structural features are to be found in the seeds, which are provided with extremely resistant coats; for it is the seeds of such species that must endure the rigors of drought and extremes of temperature of the desert. The seeds of many forms are so well protected by impervious coatings that they may be soaked in strong acids and other corrosive solutions for some time without injury to the embryo or the storage material within.

II. Perennials with woody, bulbous or tuberous stems, which are chiefly subterranean, or which lie closely on the surface of the soil.—

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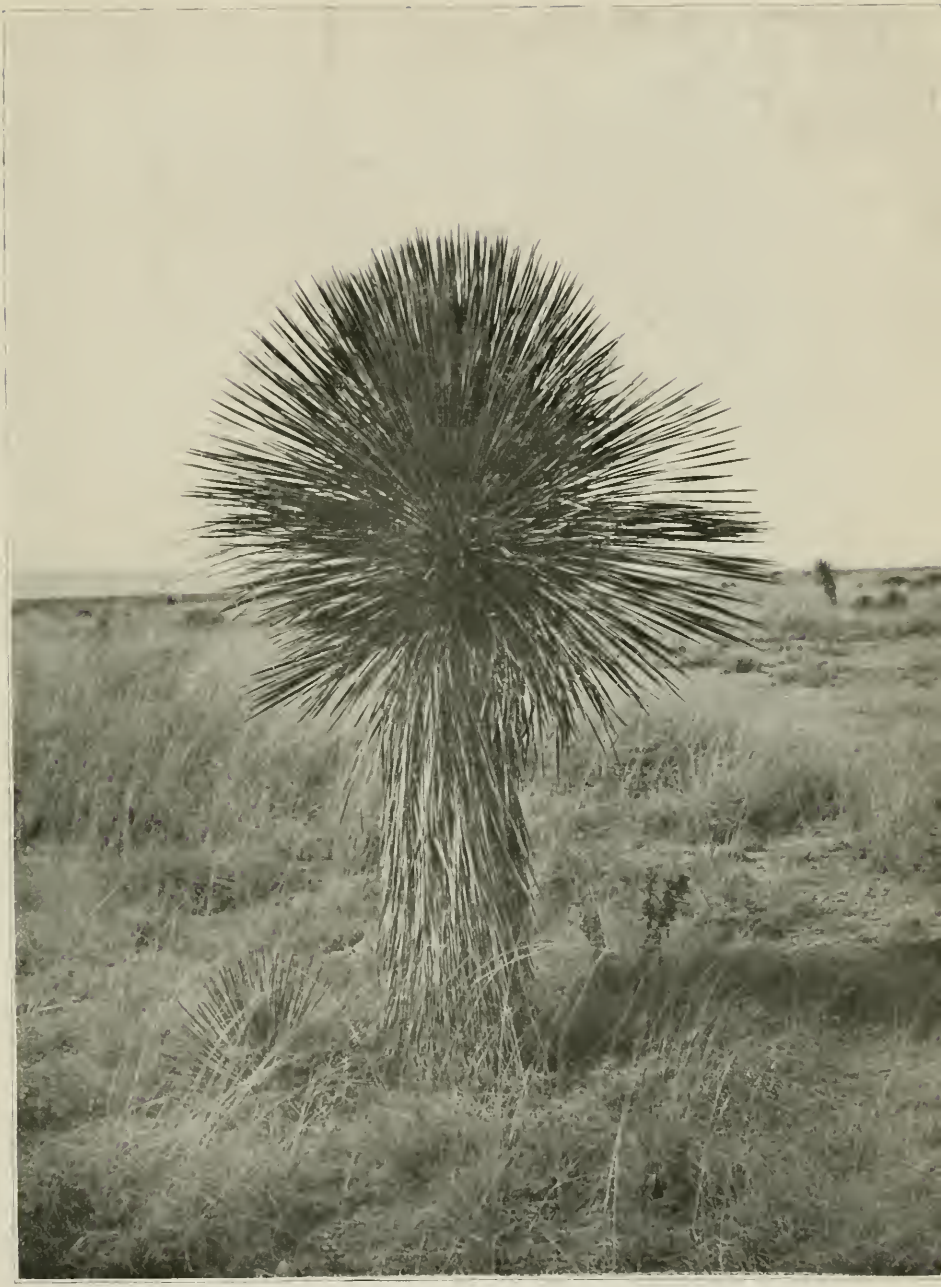
* Desert Botanical Laboratory of the Carnegie Institution. Origin and Site. F. V. Coville and D. T. MacDougal, Publication 6, Carnegie Institution. Washington, 1903.



MacDougal on Desert Vegetation. *Yucca radiosa;* young plant. Tularosa Desert. New Mexico.
By permission, Desert Botanical Laboratory. Carnegie Institution.

Plants of this group are almost entirely dormant during the season unfavorable for growth, and produce a rosette of leaves with a shoot of greater or less extension on which are borne the flowers during the rainy or favorable season. *Limonium limbatum* Small, which has recently come under the notice of the author, may serve as an example. This plant seems to be known only from near the White Sands in the Tularosa Desert in New Mexico, and during February of this year the numerous shallow "washes" that extend across the arid plain west of Alamagordo were seen to bear many thousands of the short stems of these plants bearing the grayish-brown scales and dead leaves of the previous season and having every appearance of being lifeless. When specimens of this kind were brought under suitable cultural conditions and supplied with water an irregular open cluster of elongated leaves was formed, from one of the axils of which a widely branching inflorescence arose that reached a height of 70 cm and bore numerous flowers. The maturation of the seeds was soon followed by the death of the aerial shoot and basal leaves, the plant quickly resuming the inert appearance of the previous season. (Fig. 1.)

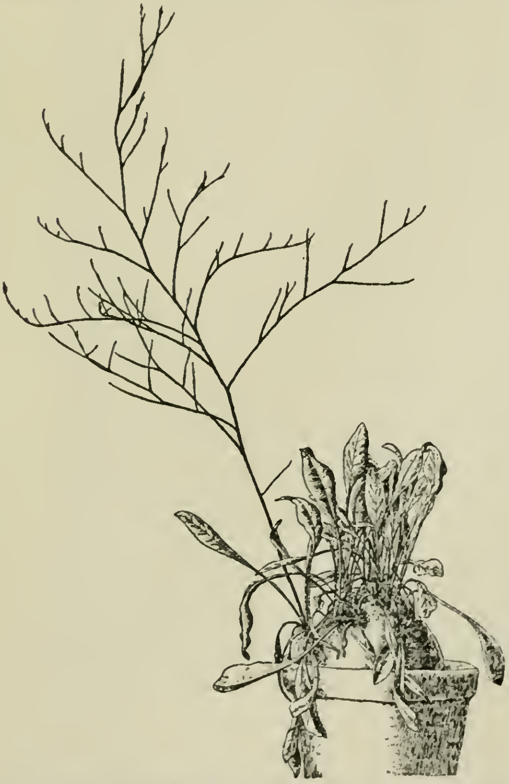


Fig. 1. *Limonium limbatum* Small. After a photograph of a plant from White Sands, N. M., cultivated in the New York Botanical Garden.

III. Perennial shrubs or trees which bear deciduous leaves. — The leaves are formed during the rainy season or under favorable conditions of temperature and are discarded during the periods of most intense aridity. As a compensation for the comparatively brief season during which the plant has the benefit of the photosynthetic activity of the leaves the stems are are generally rich in chlorophyl and carry on a limited amount of this work during the greater part of the year. This is still further supplemented by the petioles and midribs of some species which are retained while the leaflets are discarded, as may be seen in some of the Leguminosae. *Ipomœa arborescens*, the tree morning glory, may be included within this group. The trunk of this tree does not appear to be formed by the successive and progressive activity of a distinct cambium layer as in ordinary hard-wood trees, but is of a herbaceous type, and a new cambium is formed every year external to the bast, which endures only during the season in which it is formed. The entire trunk is soft, generally rich in water and storage material, while the external layers including the bark are succulent and rich in chlorophyl. The leaves are cast off during the dry season, but flowers are produced in some profusion by the aid of the water and food material stored in the trunk. *Acacia greggii*, and the mesquite (*Prosopis*) may be included in this group as well as *Parkinsonia*. The last-named tree is the "palo verde" of the Mexicans, and the amount of chlorophyl and material constructed by its activity present in the branches is so great that the tree forms a most excellent forage for cattle, horses, and deer, which also eat the branches of *Ipomœa arborescens*. The leaflets of *Parkinsonia* are often discarded while the petiole remains and carries on the leaf-functions in diminished measure. (Fig. 2.)

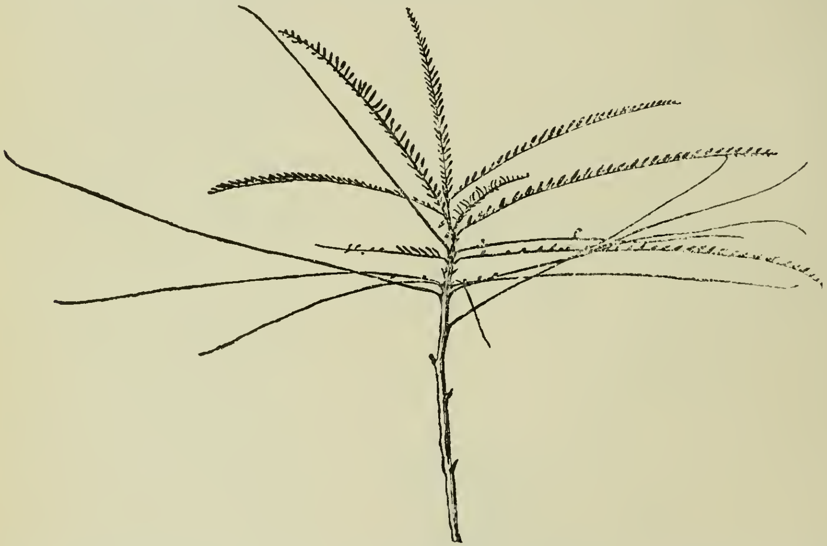
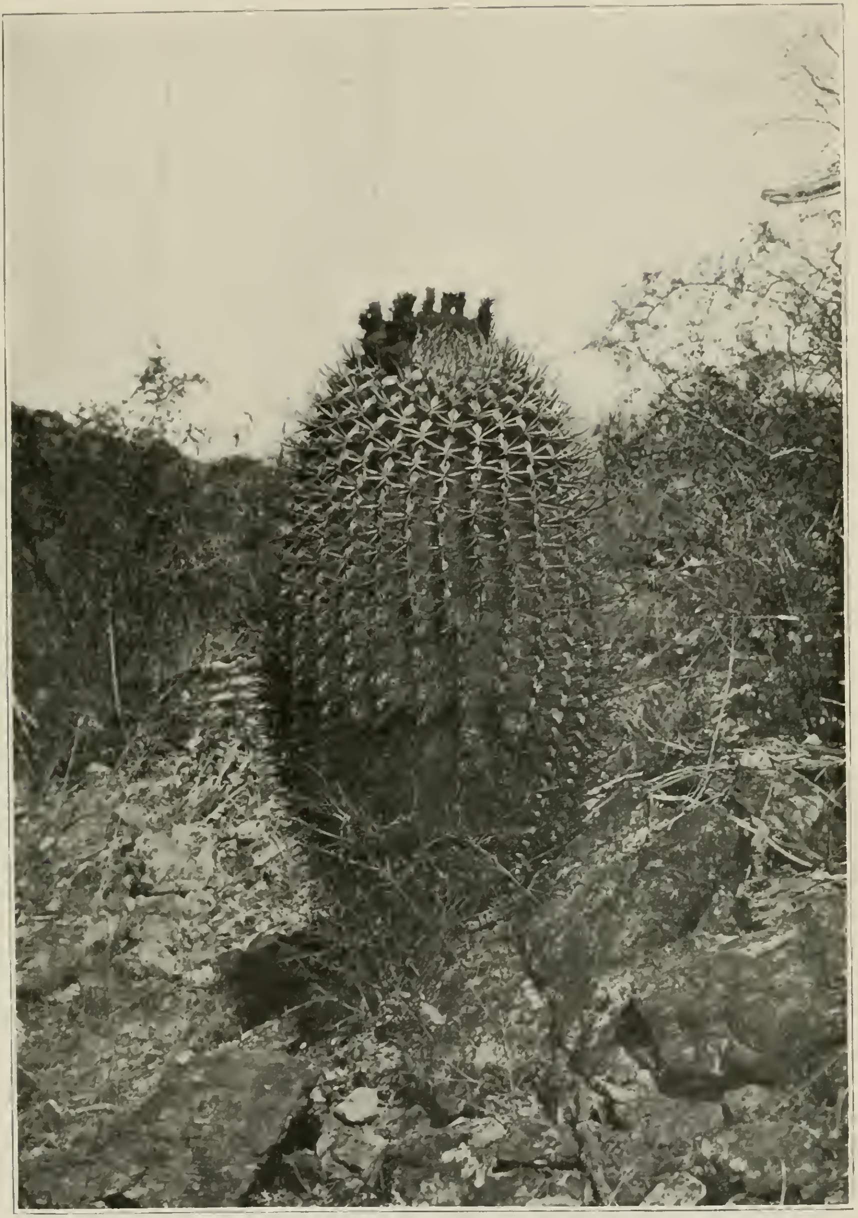


Fig. 2. Plantlet of *Parkinsonia*, some of the leaves of which have discarded the leaflets and retained the green petioles.

Another interesting variation in the method of casting of the leaves has been found in the recently discovered *Fouquieria macdougalii*. The branches of this tree are very rich in chlorophyl and continue the functions of photosynthesis during almost the entire year. The casting of the simple leaves is carried out in such manner however that the petiole is not cut off at its base near the trunk. On the other hand the line of separation begins on the lower (outer side) of the petiole near the basal



MacDougal on Desert Vegetation. *Echinocactus emoryi*, near Torres, Sonora.
By permission, Desert Botanical Laboratory, Carnegie Institution.

end of the laminae and cuts slantingly down through the petiole, reaching the upper (inner) surface of the petiole at its base. The portion of the petiole remaining is sharp-pointed and remains for a long period, making a most effective spine. (Fig. 3.)

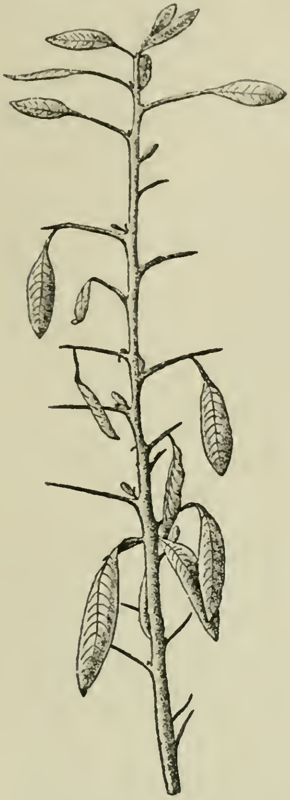


Fig. 3. Leafy branch of *Fouquieria macdougalii*, showing manner of casting of leaves, and formation of spines.

It is among trees of this group that some very extensive root-systems have been noted, the tips of the smaller roots being found many yards from the base of the trunk.

IV. Perennials of a spinescent habit with reduced leaves, which do not exhibit any marked seasonal alterations in activity, but continue development more or less slowly throughout the entire year.—The leaf-surfaces of plants of this character are reduced and practically non-existent except upon young plants, the stems and branches being highly chlorophyllose, with many marked transpiratory adaptations of the epidermis.

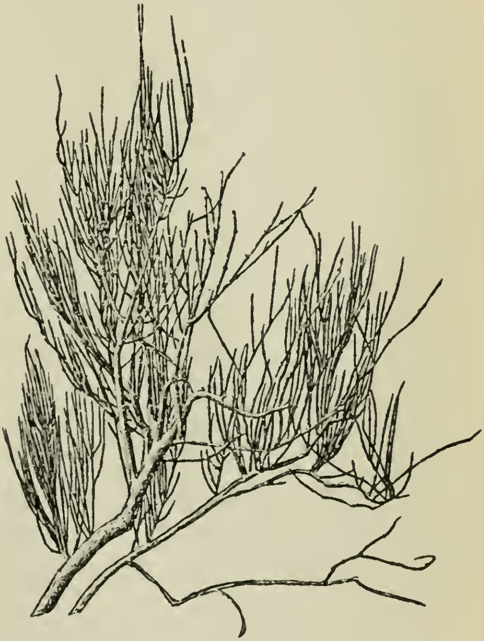


Fig. 4. *Ephedra* sp. growing in gypsum, White Sands, New Mexico.

The cortical tissues of the stems are sometimes palisaded after the manner of leaves. The spines of this group are generally atrophied branches. Not all plants which share the above characteristics form spines however.

Koeberlinia, *Holacantha emoryi*, and *Ephedra* may be offered as representatives of the group. (Fig. 5.)

V. Perennials with regular foliar organs protected by varnish, wax, resin, or other water-proof material, or furnished with a volatile oil.—One of the more common and widespread examples of this large group is the creosote bush (*Covillea tridentata*), which is a characteristic plant of extensive desert areas of North America. The endurance of the leaves varies with the locality and the conditions, but in some instances it is known to produce two crops of leaves and flowers during the year. In general it may be said that the reddish-brown resin secreted by the leaves is most abundant in the drier periods immediately following the rainy seasons. *Covillea* is not furnished with spines, but the resin is so strong in odor and taste that it is but little attacked by animals. (Pl. 35.)

VI. Perennials with succulent stems or leaves, or with other special devices for the storage of water.—This group includes a wide diversity of morphological types, and the species showing greatest capacity for storage of water are most abundant in the regions in which the rainfall occurs within a comparatively brief period. The total surface exposed from which transpiration may take place is generally comparatively small in proportion to the volume of the body of the plant. The reduction of the shoot and the adaptation of organs to water storage show the greatest diversity in different species.

In *Cereus greggii* the main root and the base of the shoot appear to be converted into a storage organ containing a large amount of water, while the shoot shows an extreme reduction. The tuberous underground portions of this plant are beet-shaped, a foot or two in length, and may weigh as much as ten or fifteen pounds. This means that an amount of water sufficient to meet the ordinary needs of the plant for a year is held in reserve. (Fig. 5.)

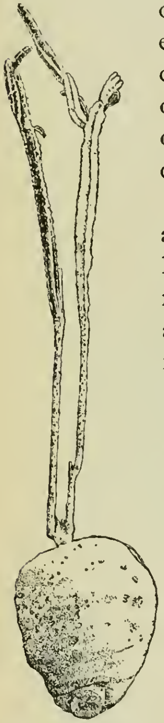
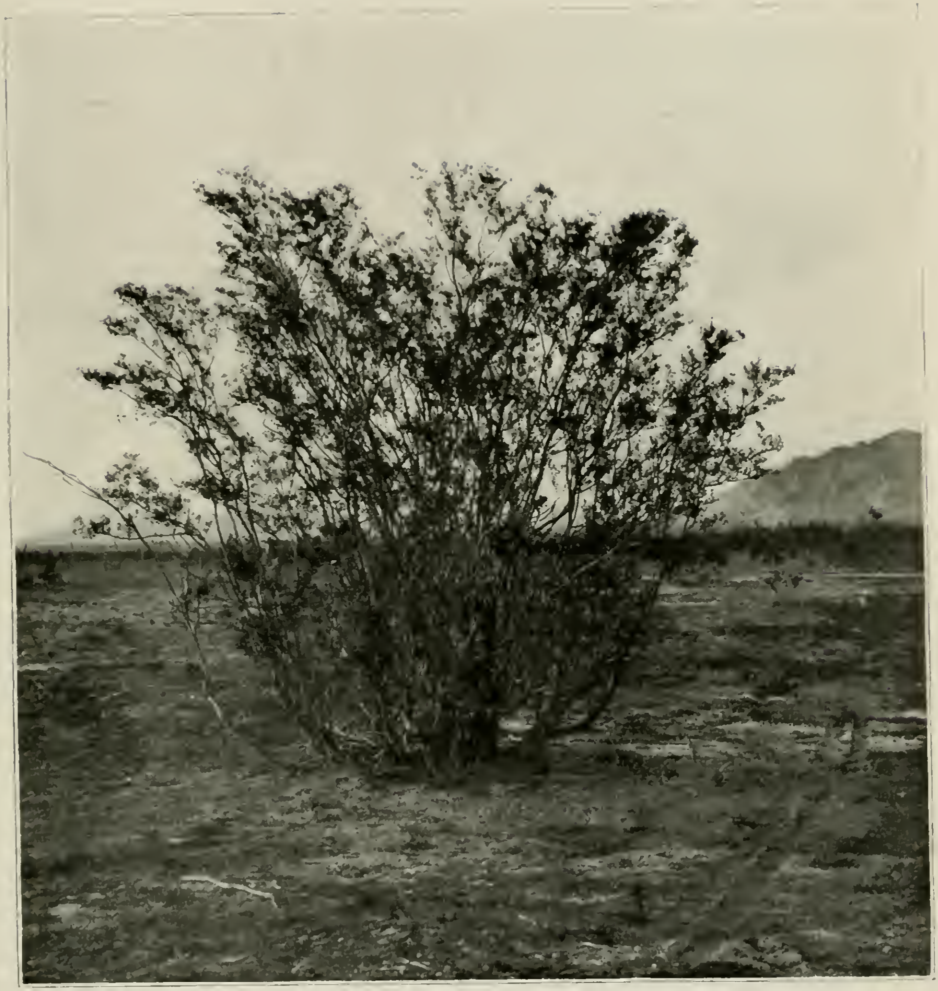


Fig. 5. *Cereus greggii*, from Tucson, Arizona Cultivated in the New York Botanical Garden.

Ibervillea sonorae, the guarequi of the Mexicans, is an example of a plant that has converted the basal perennial portion of the stem into a storage organ which holds a supply of water sufficient to keep the plant alive for years. The large compressed tubers which lie on the surface of the soil may attain a diameter of 40 cm across and half that amount vertically. The woody pulp contains in addition to water, reserve food-material and some poisonous substance, the nature of which has not yet been ascertained. It is evident, however, that it is sufficiently potent to secure the tubers against the attacks of grazing animals. The tubers may be seen lying on the sand under arborescent opuntias and acacias during the dry season, and quickly send up the characteristic leafy stems of the Cucurbitaceae upon the approach of rains. Seeds are produced within two months from the beginning of activity and the



MacDougal on Desert Vegetation. *Covillea tridentata*, near Tucson, Arizona. By permission, Desert Botanical Laboratory, Carnegie Institution.

climbing stems die back as the rains cease and the plant enters into another resting period. When in this inert condition it may be thrown about like so many pieces of wood without injury. Tubers of guarequi, which were obtained from Torres, Sonora, in February, 1902, have lain about on the metal benches in the greenhouses in the New York Botanical Garden, and occasionally start into activity. A number placed in the exhibition cases in the Museum sent out vines in 1902, and in August, 1903, eighteen months after being lifted from the soil, a second crop of tendril-bearing stems were produced in the museum cases. (See Plate XVII, Publication 6, Carnegie Institution, Washington, 1903.)

A large number of examples of this general type is offered by the flattened and cylindrical opuntias and cereuses, in which the leaves are reduced and quickly fall off, while the much reduced shoot is made of stems and branches containing a comparatively large proportion of succulent tissue. The amount of water which may be stored in such tissues may be sufficient for all of the needs of the plant for many months and perhaps more than one season. It is characteristic of this type that the water-storage tissue is found throughout the entire shoot, so that when a single section or "joint" of such a stem is detached it carries with it a supply that may enable it to propagate the plant under the most arid conditions. The presence of spines on nearly all of the plants of this type prevents their extermination by animals, which would otherwise soon destroy them for the water to be obtained from them. During seasons of extreme drought, ranchers sometimes cut great numbers of opuntias and burn off the spines by means of fires of brushwood and then feed the denuded branches to cattle and other animals. (Pl. 36.)

The large barrel-shaped echinocactuses consist of a great swollen stem and a root-system penetrating the rocky and sandy soil in all directions. It is impossible to calculate the practical storage capacity of these plants, but even the most casual inspection would tend to show that a supply of water equal to the entire transpiration of the plant for years is kept in reserve. The Indians of southern California, Arizona, and Mexico habitually make use of this supply when traveling in arid regions away from pools and streams. (Pl. 34.)

The yuccas may be used to illustrate a different type of plant exhibiting water storage. In many of the species of this family huge rosettes, or crowns of long, tapering, fleshy leaves are formed, which in some species have a capacity for the storage of large quantities of water and food-material. The arrangement of the sharp-pointed leaves, and the further devices of cutting edges and spines prevent plants of this type also from being plundered by animals for the sake of the water. (Pl. 33.) Water storage in leaves is also exhibited by *Lycium fremontii* and other species of the genus, the small obovoid leaves of these shrubs being rich in water and easily detachable from the plant. In this instance a large number of animals make use of the leaves as a water supply, eating both leaves attached to the branches and those which have fallen to the ground.

VII. Species adapted to soils containing large proportions of soluble salts.—Great areas in deserts have soils from which the soluble salts are not washed by reason of lack of rainfall, and in certain places around saline springs and alkaline pools the concentration of the salts is extremely high. Many of the plants capable of living in soils of this character show the same structural adaptations as those of the saline districts near the seashore, being truly halophytic in character. The stems and the leaves of some species are succulent and are brittle, being easily broken into fragments. A good illustration of the features of halophytes may be obtained by a comparison of the two eastern species of *Tissa*, one of which, *T. marina*, is an inhabitant of sandy salt-saturated soils and the other is found on arid ridges and on dry hills. Quite a number of forms are characteristic of the saline and alkaline regions in western deserts, among which may be mentioned the salt-bushes (*Atriplex*) and *Allenrolfea*, while *Juncus Cooperi* may be cited as the case of a plant which finds suitable environment only in the briny wet soils around saline springs and has been collected only in the Mohave and Colorado Deserts, and in the Death Valley region. (Pl. 32.)

The most important features then of the environment encountered by desert vegetation consist in scanty and unequally distributed water supply, coupled with high concentration of soil salts in most instances; an extremely dry atmosphere, with the occurrence of high air and soil-surface temperatures. The actual difference of temperature between the root and shoot is quite unlike that of plants in moist regions, and as I have previously pointed out, must be of great influence in all of the vegetative processes.*

The general features of desert vegetation offer some most alluring problems in the study of the origin of species. Here a general interpretation of the face of nature might lead one directly to the conclusion that xerophytic species are examples of a direct adaptation to environmental factors and the consequent development of forms adapted to these conditions. This alluring generalization has the academic advantage and disadvantage of being most difficult of proof and disproof and may be supported only on theoretical grounds, for no one has ever actually seen a species arise in this manner, and for every argument brought forward to support the theory, the advocate of natural selection will adduce equally cogent, and quite as theoretical proof, that desert forms arose otherwise. The study of the extreme types presented by the vegetation of arid regions might

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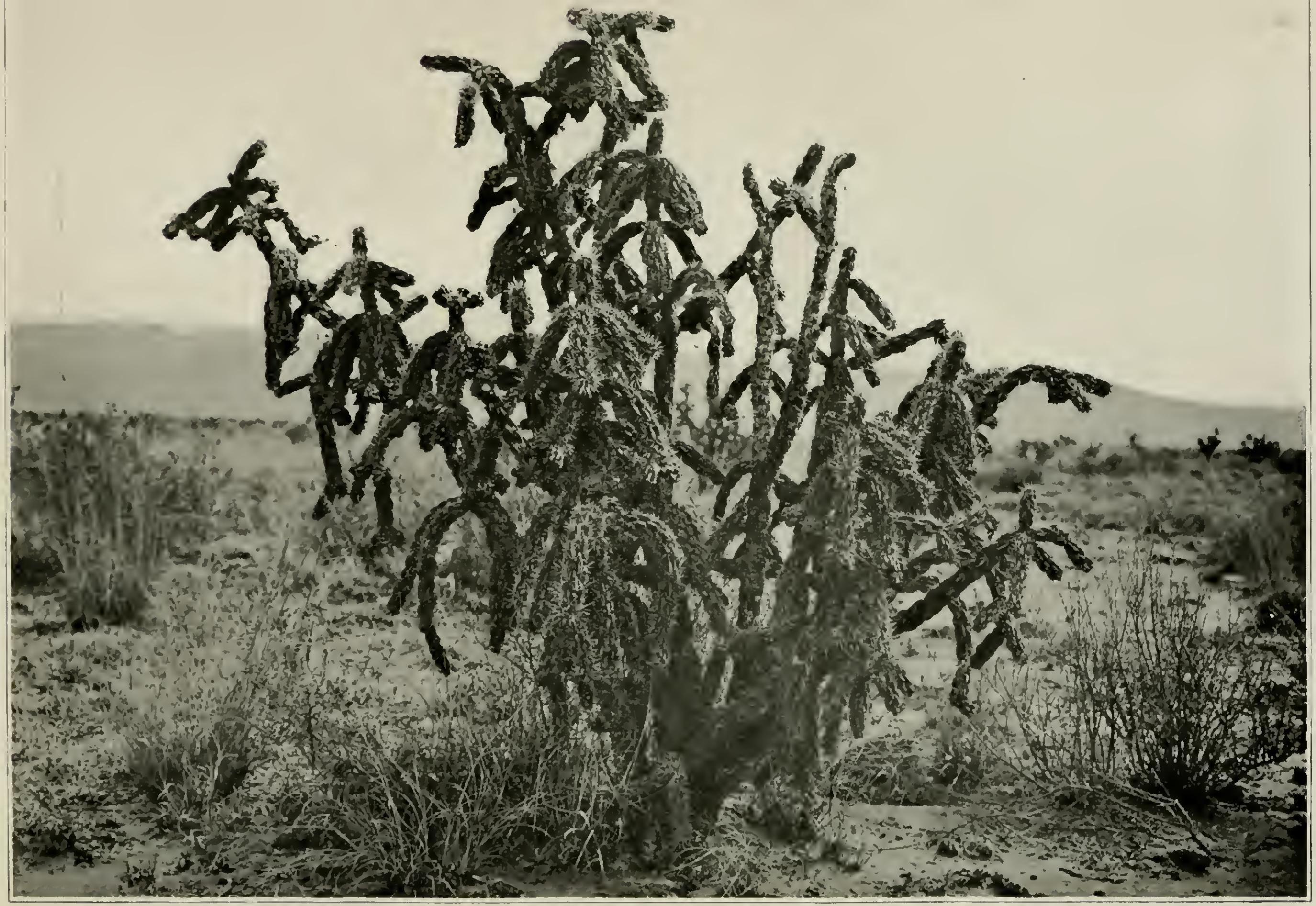
* MacDougal, D. T. Soil Temperatures and Vegetation. *Monthly Weather Review*, 31:375, 1903. Washington.



MacDougal on Desert Vegetation. *Opuntia arborescens* in Tularosa Desert, New Mexico. By permission, Desert Botanical

well lead to some positive evidence upon the general method of origin of species, and if the entire effort of the Desert Laboratory inquiry resulted in bringing to light positive evidence as to the actual origin of two species of plants its energy would have been well expended by reason of the value of such results to evolutionary science in general.

The long standing questions as to the causal facts in regard to the various protective structures of xerophytes have advanced but little toward their final solution in the last decade. Are the spines, thorns, prickles and poisons of desert plants really the results of efforts on the part of the plant for self-protection? So many of the special features of xerophytic vegetation have been interpreted in the spirit of an enduring optimism that leans on the future for a confirmation of its conclusions, which have been received with patient credulity by the botanical world, that it is necessary to ask ourselves the most elemental questions about the best known and most apparent features of the vegetation of the desert.

Not the least interesting of the results to be obtained from studies of the plants of arid regions, are those which may be expected as to the physiological and mechanical causes accountable for the remarkably low density of distribution, one of the most highly characteristic features of the flora of the desert.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL GARDEN—No. 47

ANATOMY AND PHYSIOLOGY OF BACCHARIS GENISTELLOIDES

By ELSIE M. KUPFER

NEW YORK
1903

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Anatomy and Physiology of Baccharis genistelloides

By Elsie M. Kupfer

Baccharis genistelloides Pers. is an inhabitant of the mountains of Peru, growing in dry places at an altitude of about 1200 meters. It has several well-marked varieties which apparently spread north into Ecuador, and south and east into Brazil. The typical form is a slightly shrubby plant of extremely peculiar appearance. The leaves are atrophied, being represented by minute scales scarcely more than 2 mm. in length; and the work of photosynthesis is assumed by conspicuous wings which stand at three equal angles from each other. The scales are arranged in three orthostichies, and two wings originate from the base of each scale. One of these wings runs through only one internode and terminates at the margin of the scale below; the other, in each case, runs through two internodes until it is similarly stopped. This alternation of a long and a short wing in each orthostichy, as well as the fact that the wings (following the phyllotaxy) twist spirally, accounts for the curious appearance of the plant represented in *f. 1*.

While the shoot is almost uniformly leafless in the upper portion, usually one, two, or even several normal leaves are to be found near its base. They are of moderate size, obovate and somewhat thickened (*f. 2* and *3*). The genus *Baccharis* is a large, and as far as leaf-form is concerned, a heterogeneous one. The leaves of many species, *e. g.*, *B. floribunda* and *B. trinervis*, are large, thin and smooth; others, as those of *B. alpina* and *B. microphylla*, are minute and thickened; *B. aphylla* and *B. gracilis* have only narrow phyllodes; and, finally, *B. genistelloides* and *B. fastigiata* are devoid of foliar leaves. The leaves of several of the species, however (and it is significant that these are generally South American species), particularly *B. dioica* and *B. cassinaefolia*, closely resemble in shape, size and texture the juvenile leaves of *B. genistelloides*. There is every reason, then, it seems to me, for considering this form as that of the ancestral type.

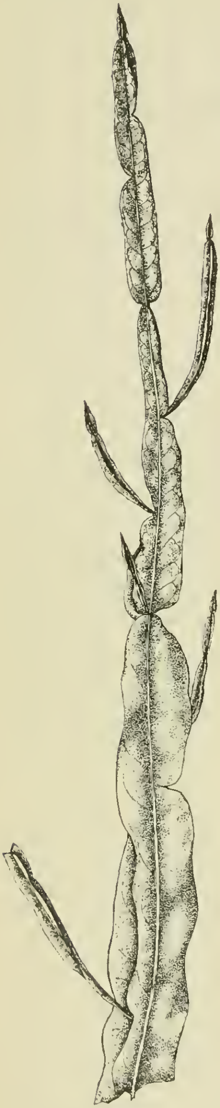

FIG. 1. Shoot of *Baccharis genistelloides.*

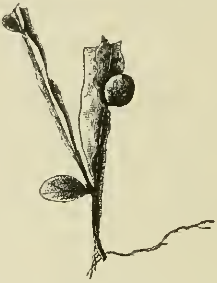

FIG. 2. Shoot from base of plant of *Baccharis genistelloides*, showing leaves.

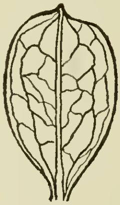

FIG. 3. Single leaf of *Baccharis genistelloides*, natural size.

The seeds, unnamed, were brought from Peru by Mr. de Lautreppe in 1900 and planted in the New York Botanical Garden. Because of the ignorance as to their identity, little attention was given to the plants until they had attained a considerable size; so that unfortunately none of the early stages has been observed. At the present time, in the beginning of their third year, the plants are about 1 meter high. The stems near the base are secondarily thickened, and the wings there are either much thickened or have been entirely lost. Several of the plants flowered in February, 1902, and again in December, 1903; but although the flowers were pollinated, the seeds produced were exceedingly minute and failed to germinate.

Noteworthy adaptations to an environment both of strong light and excessive dryness come to light on an examination of the anatomy and physiology of the plant.

THE EPIDERMAL SYSTEM

The protective system of the plant is very well developed. There is a considerable covering of wax over the whole plant (cf. *f. 9*). In addition, the epidermal cells are cuticularized both without and within; and particularly in the younger portions, the surface is covered with peculiar hairs, of which usually only the end-cells project above the wax. The stomata are exserted and are apparently sensitive. The *wax* is laid down in the form of irregular plates fitted together into a sort of mosaic. In the younger portions, to about 3–7 cm. back of the tip, the waxy covering is very thick, while the outer layers are shed in the form of powdery scales. Its very ready solubility in ether indicates its fatty nature. The *cutin* is present in a layer over the entire plant even up to the very tip of the growing point, though, naturally, it has less thickness here than in the older parts of the plant. The surfaces of the leaves present on the lower parts of the plant are more heavily cutinized than either the wings or the stem.

The *hairs* almost always arise in pairs from two adjacent epidermal cells. In most of the members of this family, as Vesque,* whose observations have been confirmed by more recent investigators, points out, two kinds of hairs are to be found: glandular hairs and mechanical hairs. Both kinds are present in this plant. The gland-hairs, which are composed of double series of from 3–5 cells each, differ from those mentioned by Vesque and Solereder † in that all but the end-cells contain chlorophyl. The cutin is but slightly raised by the not very abundant secretion, the nature of which has not been any more definitely determined than that it is odorless and soluble in ether (*f. 4*). That the secretion of wax is to be assigned to the epidermal cells in general, and not particularly to these hairs, seems probable from the fact that few or none of the hairs are to be found on the older portions of the plant, where, nevertheless, the wax is abundant.

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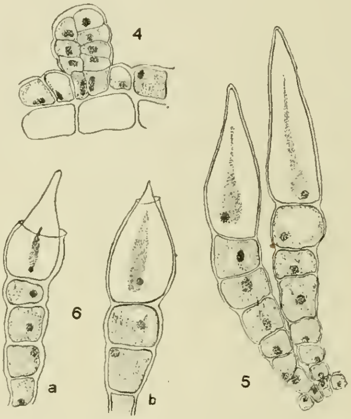
* Vesque, T. Caractères des * * * Gamopétales. Ann. Sci. Nat. Bot. VII. 1: 183. 1885.

† Solereder, H. Systematische Anatomie der Dikotyledonen. 515 ff. 1899.

The whip-hairs, too, seem to differ from the types of Vesque in that they are also, as a rule, bicollateral. They are thus apparently homologous with the gland-hairs. The early condition of the two kinds of hairs is very similar, the only difference being that the whip-hairs are from the beginning devoid of chlorophyl. In the adult condition, however, they are entirely separated from each other. The enormously enlarged end-cells have walls so highly thickened that the cell-lumen is almost obliterated (*f. 5*). The developing whip-hairs are cutinized almost from the start. When fully formed they are also uniformly covered with cutin, but there is a stage in their growth in which the base only of the end-cells is surrounded by a collar of cutin, while the thickened cellulose wall of the upper part shows prominently above and through it (*f. 6 a* and *b*). Probably the cell in its period of hypertrophy breaks through its cutin covering, which is reëstablished after growth has ceased. The two whip-hairs often fail to develop simultaneously, so that a pair is frequently found, one of which is still in its prime, while the other consists of only shriveled empty cells. As far as has been determined, new hairs of either kind are not developed much below 5–6 cm. from the tip. As some also drop entirely off, the hairs on the older portions are very scattered and frequently consist of only the shriveled cells.



Hairs of *Baccharis genistelloides*. FIG. 4. Gland-hair. FIG. 5. Two whip-hairs. FIG. 6, *a*, *b*. Developing whip hairs.

It is difficult to determine the function of either kind of hairs, if they have any. In the younger parts, where alone the hairs are plentiful, they are often entirely embedded in the wax. The gland-cells are usually thickly covered, while occasionally part of the end-cell of the whip-hair protrudes beyond. Of what use can a secretion be, the escape of which is entirely prevented? In the cases among the Compositae in which the whip-hairs are found, they are usually present as Vesque shows as a tomentum. Probably here, as in *Chrysoma pauciflosculosa* described by Professor Lloyd, they are functionless.*

The *stomata* are evidently of a motile type (*f.* 7). They are provided with distinct accessory cells, so that this plant adds another to the list of composites so provided, although Benecke † declares these cases rare. Both upper and lower walls taper into very finely pointed ridges. No trace of a hinge has been discovered by me, but the cutin seems thinner at the junction of the guard and accessory cell. The accessory cells raise the stomata somewhat above the level of the epidermis. They are more exserted on the stem than on the wing.

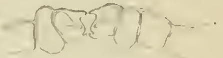


FIG. 7. Stoma from stem of *Baccharis genistelloides*.

THE STEM

In the plants examined, the stem varies in thickness from 1 to 4 mm. In the younger portions, to about 12 cm. from the tip, the supporting tissue consists largely of sclerenchyma, the wood proper being confined to a very narrow ring about 25 μ in diameter. The masses of bast-fibers are found at intervals around the stem, but the six largest masses are opposite the three wings and half way between them respectively (*f. 8*). These bast-fibers are strongly lignified, so that they give a much more pronounced reaction with phloroglucin than the young wood-ring itself. The lignification of the bast-fibers begins very near the growing tip; signs of it can be found at the distance of 1.5 cm. therefrom. This early acquisition of lignin would seem to indicate a very slow rate of growth — a point which will be recurred to presently.

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* Lloyd, F. E. Anatomy of *Chrysoma pauciflosculosa*. Bull. Torrey Club, **28**: 445. Au 1901.

† Bot. Zeit. **50**: 570. 1892.

The bast-bundles lie so close to the circle of wood — a feature according to Solereder characteristic of the Compositae — that no cambium was distinguishable as such in any portion of the stem of the growing plants. There are a number of thin-walled irregular cells between wood and bast, most of which are sieve-tubes; but some must be of a meristematic nature, because the wood-cylinder gradually increases in diameter so as to be about 60 mm. at a distance of 15 cm. from the tip, 125 mm. at 19 cm., and 166 mm. at the base of the plant examined.

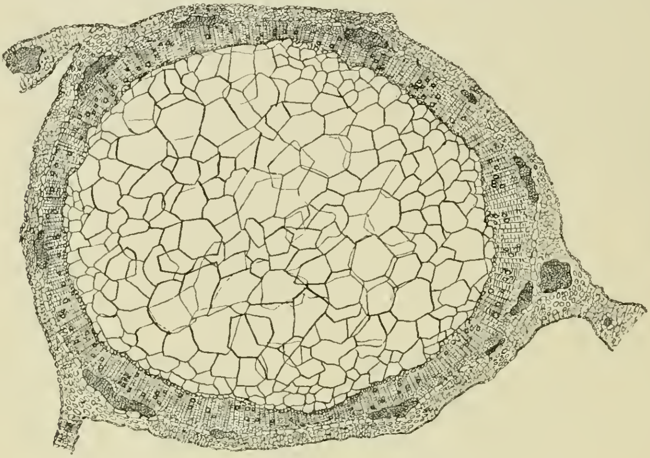

FIG. 8. Cross-section of stem of *Baccharis genistelloides*.

In an older stem taken from a herbarium specimen there were present three definite wood-rings and a very clearly established cambium layer. The wood on maceration was found to contain spiral, pitted and annular vessels. Wood parenchyma is abundant, but the medullary rays are obliterated. Around the primary bast-masses when they occur, otherwise external to the sieve tissue, an endoderm of one layer of rather large clear cells extends. Outside of this lies the cortex, of three or more rows of chlorophyl-bearing cells. Outside of the bast-bundles, however, these cells lose their chlorophyl and become collenchymatic. The angles of the older stems from which the wings have been lost become heavily suberized.

APOGEOTROPISM

The stems of *Baccharis genistelloides* are markedly apogeotropic. A number of the branches of plants which have been grown in a moist greenhouse have fallen down from their own weight. In all cases, however, the tips have turned perpendicularly upwards, and the plants present a very striking appearance in consequence. They are markedly different from the diageotropic shoots of *B. halimifolia*, which is growing in the same place. That this falling down of the branch is also characteristic of the plant in its natural environment is seen from herbarium specimens. There are often as many as six upright branches from one prostrate one.

THE WING

The wings are the conspicuous portion of the plant; they vary in width from a few millimeters at the youngest portions to 2 cm. at the older. The length depends upon their relation to the internodes. As shown above (*f. 1*) some wings go through only one, others through two internodes, the longer ones being from 10–18 cm., the shorter from 3–8 cm. A transverse section (*f. 9*) shows a very compact structure. There is no definite palisade or spongy tissue. Several rows of chlorophyl-bearing cells packed more or less closely extend inward from both surfaces. The air spaces, which are comparatively few, are chiefly situated in the middle of the wing. The stomata are approximately equal in number on both sides of the wing, averaging 70–80 to the square millimeter.

The wings are notably rigid; this is due to the occurrence of strands of mechanical tissue which are developed in connection with the vascular bundles. The conducting tissue plays but an unimportant rôle in the support of the wing. There is a particularly large stereome mass on the extreme edge, which is readily removable as a thick thread.

In order to determine the morphology of the wing, serial sections of the growing point were prepared. From these it appeared that the wings are directly continuous with the margins of the scales. On comparison with shoots bearing true leaves this view was substantiated. In the terms of many of the text-books, then, these wings would stand as "decurrent leaves" — as elaborations of the leaf-base, named by Vines the "hypopodium." Their peculiar phyllotactic arrangement would thus obviously be explained. The question was raised however as to whether these facts alone *i. e.*, the connection with the leaf-base and their phyllotactic relation, would be sufficient to establish the homology with leaf-structures. The point was decided in the negative for the following reasons :

1. Their main axes, even at the growing point, are parallel to the stem, instead of at a greater or less angle as in other developed leaf-bases, *i. e.*, stipules.

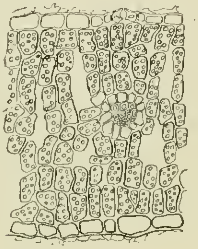

FIG. 9. Cross-section of wing of *Baccharis genistelloides*.

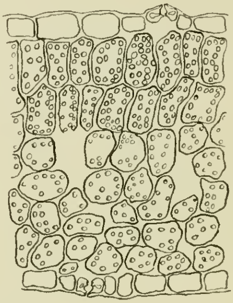

FIG. 10. Cross-section of leaf of *Baccharis genistelloides*.

2. In many plants, *Lathyrus latifolia*, *L. sylvestris* and *L. grandiflorus* among others, both stipules and wings occur. In such cases the wings, although just as obviously continuous with the wings of the petiole, evidently could not be hypopodia.

3. Other organs have been found that follow the leaf arrangement, but may not therefore be supposed to be leaf-structures — for example the thorns in some species of *Rubus* and *Smilax*, the ridges in the stems of *Urtica gracilis*, *Mentha crispa* and *Leptandra Virginica*.

For these reasons the wings are, it seems to me, rather to be regarded as lateral-vertical expansions of the stem than as "decurrent leaf-margins."

PHOTOTROPISM

To determine the action of the plant towards light a growing shoot was fastened in a dark chamber illuminated from one side only. After fourteen days there was found to be a decided phototropic reaction. The stem had turned towards the light, the bending region extending to about 3 cm. from the tip. The two wings nearest the aperture had turned at right angles to each other and in the direction of the rays, the third wing had moved to a position just behind and parallel to one of the others. In this way only its very edge was illuminated. Although at first it seemed as if the wings must have played a positive part in the movement towards the light, probably a purely mechanical explanation is to be assigned for their position. By experiment it was found that these would be the positions assumed by any rigid objects — such as strips of cardboard — fastened to a bending axis, so that probably only the stem was directly concerned in the reaction.

THE LEAF

The leaves themselves vary in size. The largest found measured 2.2 × 1.3 cm., the smallest 5 × 3 mm. (*f. 3*). They appear, as above pointed out, at the basal portion, but also occasionally on new shoots, developing from buds on these regions. A transverse section of the leaf (*f. 10*) shows that here also we have a fairly compact mesophyl structure. The intercellular spaces are, as in the wings, comparatively small. In the leaf, however, sharply distinguishing it from the wings in structure, we find a noticeable dorsi-ventral differentiation; for not only has the leaf a definite palisade parenchyma of two layers of cells, but a difference is also to be observed in the number of stomata present on the two surfaces. There are 106 stomata to the square millimeter on the lower surface to 50 on the upper. It is to be noted as significant that the whole number of stomata per square millimeter would average almost exactly the same in the case of the wing and the leaf.

REVERSION TO THE JUVENILE LEAF-FORM

Several experiments were started with a view to inducing the re-formation on adult shoots of the juvenile leaf-form. Some of the growing shoots were kept in a moist chamber, others in a dry and still others in a dark chamber for several weeks, but no results were obtained. This may have been due to one or more of several causes. First, of course, these particular agents may not induce leaf-formation in this plant; or again the failure may have been due to the fact that growing shoots (and therefore shoots very far from the usual basal region of leaf-production) were used; or finally, it may have been due to the fact that all the shoots which were experimented with formed flower-buds on being released, as it is believed that when a shoot has once laid down the primordium of a flower it is thereafter unchangeable.

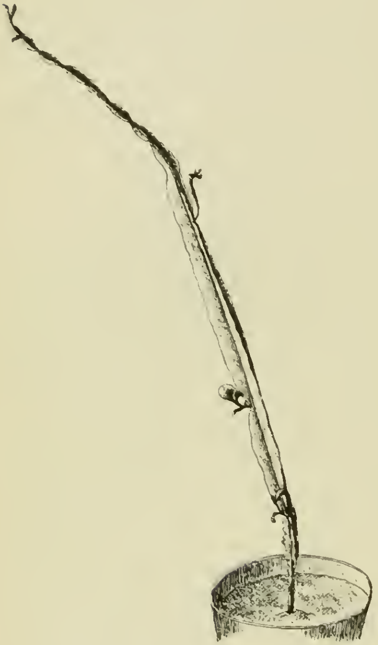

FIG. 11. Cutting of *Baccharis genistelloides*, showing production of juvenile aves.

To avoid the repetition of these conditions it was determined to defer the experiments until such a time as separate plants would be available for the different experiments. For this purpose, but also more particularly to determine the effect upon the leaf-reversion, a large number of cuttings were made, consisting, of course, of the youngest shoots, *i. e.*, those farthest from the juvenile character. The cuttings were difficult to root; less than half of those planted at three different times succeeded. At present, however, there are about 15 more or less healthy young plants.

On three of the cuttings which were planted earliest, reversion shoots of a remarkable character developed. The first one to be affected produced from buds two branches, on each of which appeared three reversion leaves, and on which the wings were reduced almost to a minimum. Also (and this seems extraordinary) the main shoot produced near its apex several smaller leaves. This is the plant represented in *f. 11*.

On the second plant a similar set of phenomena was observable. Three shoots bearing some of the largest leaves that have been found and the greatly reduced wings appeared, and at the same time the tip of the shoot continued to produce leaves as it grew.

On the third the main shoot withered; and one of the buds produced a branch on which the wings are apparently normal, but on which three small leaves have been found. Four other plants produced leaves on branches that retained their wings.

The apogeotropic habit of the secondary branches made another experiment possible. A plant on which the main branch had fallen from its own weight and on which there were a number of such upright shoots was layered — that is, had its main stem covered with earth. After allowing the branches to rest in this condition for some time, the connection of the vertical shoots with one another and with the main stem was severed. However, although all the shoots flourished and grew into separate plants, none produced the leaves.

To sum up briefly the most important points brought out in this investigation:

1. *Baccharis genistelloides* is a plant remarkably well adapted by the loss of leaves, by the position of the wings, and by the coverings of the cutin, wax and hairs, to withstand a high degree of both dryness and insolation.

2. The glandular hairs differ from the hairs previously described in the Compositae in the possession of chlorophyl, and the whip-hairs in being biserial.

3. The early acquisition of lignin in the bast of the stem, and of mechanical tissue in the wings, gives to the plant its characteristic rigidity, and at the same time necessitates a short period of elongation.

4. The leaves found in any given portion of the stem on the older parts of the plant resemble closely the leaves of other species of *Baccharis*.

5. The leaf differs from the wing in structure in showing marked dorsiventrality, which is absent in the latter.

6. While the wings are directly continuous with the margins of the scales and of the leaves when present, and while they follow the phyllotaxy, they are to be considered morphologically as lateral-vertical expansions of the stem and not as "decurren leaves."

7. The shoots have been shown to be markedly apogeotropic and positively phototropic.

8. Cuttings of growing shoots were made, a number of which after rooting produced branches which bore reversionary leaves and greatly reduced wings; the apices of the old shoots also produced the leaves in two cases.

The thanks of the author are due to Dr. D. T. MacDougal, under whose direction the work was carried on, and to Prof. F. E. Lloyd, for many valuable suggestions.

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MUTATION IN PLANTS

BY DANIEL TREMBLY MACDOUGAL

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MUTATION IN PLANTS[1]

D. T. MACDOUGAL.

It is presumably safe to say that all students of natural history agree in the opinion that living matter has qualities at the present time that it did not originally, or always possess, and furthermore it is universally conceded that protoplasm is undergoing such development that it is constantly acquiring new properties, and taking form in an increasing number of types, kinds, or species of organisms as a consequence. In other words living matter is increasing the number of its qualities, multiplying the number of forms in which these qualities are variously grouped, and at the same time undergoing such differentiation that an increasing complexity is the general tendency of the organic world. These facts once realized the biologist finds himself confronted with two stupendous interrogatories. By what method is the general development and differentiation of organisms brought about as expressed in the formation or origin of new species, and secondly what are the general factors which shape this progression? The amount of mere discussion ensuing from the presentation of conflicting views brought out by these questions, in comparison with the total scientific effort to obtain positive evidence upon the points involved is appalling to contemplate. Happily the biological world is becoming intolerant of wrangling and speculative contentions, and has earnestly set about finding the facts that will afford an adequate and satisfactory solution to the main problems. The cult of the study of statistical variations may be regarded as one expression of this newly assumed attitude, while the devious, intricate and oft-times labyrinthine ways of cytological investigations have, or should have, their chief purpose in the discovery of the physical mechanism of heredity.

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[1] The general discussion of the mutation theory embodied in this paper, together with an exhibition of the seedlings of Œnothera was given before the Zoological Seminar of Columbia University, April 23, 1903. The comparisons between the mutants were not completed until August, 1903.

The terms *discontinuous variation*, or *mutation* in connection with the study of inheritance, descent, and the origin of species may be taken to mean the autonomous physiological processes by which one or more individuals of a species give rise to offspring which exhibit qualities, or groupings of qualities not possessed by their immediate ancestors and not previously exhibited by the individuals comprised in the parent species (progressive mutation), or by which one or more individuals give rise to individuals lacking qualities or groupings of qualities exhibited by the ancestral forms (retrogressive and degressive mutation). These aberrant individuals or mutants may transmit their characters to their offspring in such a manner as to give rise to a new line of descent constituting the origin of a new type by mutation.

The number of freaks, sports, bud-variations, and specimens of plants with abnormal forms and sizes of leaves, stems, and flowers, some of them highly teratological, to which attention has been called by various writers in botanical periodicals under the designation of mutants makes necessary the emphasis of the fact that observations on a single individual, or a single generation of individuals are of but little value in distinguishing fluctuating variations from mutations. Results worth a moment's consideration may be obtained only by the most careful exclusion of the possible effects of disease, of animal or plant parasites, of hybridization, and by a careful analysis of the phylogenetic value of the divergences as tested by observations on successive generations of living forms. It is in this manner, and in this manner alone, that discontinuous, saltatory variations may be distinguished from the results of common, fluctuating and individual variability. Mutation rests in the main upon such substantive, discontinuous variations as the acquisition of new characters, or the loss of old ones hitherto transmitted by the parent type, or upon simultaneous alterations of both kinds. These changes may be accompanied by, or may result in, the masking of current qualities, or the unmasking and energizing of latent qualities of the parent type.

The essential differences between the two processes appear to have been originally set forth by Charles Darwin,[1] and are treated at length by deVries. The formal distinctions drawn by deVries appear to need some slight modification and elaboration in order to make them universally applicable. Thus he holds that continuous, or fluctuating variability occurs only in accordance with Quetelet's laws, and that it involves only the number, size and weight of organs, and does not include differences in qualities. Cultural experiments of various kinds during the last few years have given results in which the qualities as well as the number, size and structure of organs have been materially altered, but such induced variations or divergences were not transmissible. This particular factor in distinguishing between fluctuating and mutating variability therefore becomes a safe one, when it is modified to make mutating variability include only newly acquired and transmissible qualities. The presence of a plant or an animal parasite may not only change the mechanical features of an organ but may also cause most radical alterations in its physiological properties. A single example of the latter may be cited in the case of the common species of Euphorbia in which the affected leaves alter their geotropic sensibility in such manner that they change from diageotropism to apogeotropism. Such variations are not transmissible however, and in this lies the true test between mutation and fluctuating variation. A still further distinction consists in the fact that mutations ensue in the rudimentary state of the individual, while the alterations in qualities induced by any of the above factors in fluctuating variability may be caused in various stages of the development of the individual, but in a rudimentary stage of the organs concerned. Mutative alterations arise with the individual, are not the direct result of external factors, and are perfectly transmissible, while fluctuating variations may arise by the influence of external factors at various stages in the individual development, and are not transmissible in their entirety.

Much of the confusion inevitable to any discussion of the subject may be avoided if it is borne in mind that we habitually gations have, or should have, their chief purpose in the discovery of the physical mechanism of heredity.

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[1] DeVries. *Mutationstheorie*, Bd., 2, 1903

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Much of the confusion inevitable to any discussion of the subject may be avoided if it is borne in mind that we habitually within the last three years and it will not be profitable to rehearse the details at this time. Briefly stated deVries's investigations may be embodied in the following paragraphs.

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[1] DeVries. *Mutationstheorie*, Bd., 2, 1903.

1. Observations were chiefly concerned with a large number of plants growing wild and under cultivation, of the type of *Œnothera lamarckiana.* The identity of the parent form was found by comparison with the original description of the plant made a century earlier, and by comparison with a type specimen in the Muséum d'Histoire Naturelle in Paris collected in 1788. The actual name of this plant in the revised nomenclature is a matter of minor importance in the present connection.

2. Numbers of individuals of the parent type, as a result of cross- and self-pollination indifferently, constructed seeds which developed into independent forms, constant and self-maintenant, which differed in habit, structure, stature, appearance and properties from the parent type.

3. The aberrant or mutant forms might be divided by characters as sharp and numerous as most of the so-called minor species of the systematist.

4. No forms intermediate between the mutants, or between the mutants and the parent type were found.

5. That the mutant forms were really groups of phylogenetic value was proven by their behavior when crossed with one another, with the parent form, and with other species in the same genus. The hybridization experiments with these forms has yielded some exact evidence as to the preponderance of phylogenetically older characters by reason of the fact that the mutants are forms the exact ages of which are known. Of the crosses of *Œ. lata* and *Œ. nanella* with the parent form, from a half to three-fourths were found to be of the parent type, and the remainder of the mutant type form. The crossing of mutants with each other produces a generation many of which show reversionary characters. The mutation hybrids are constant in succeeding generations. The separation of antagonistic characters in the first generations is weighty evidence in support of the theory of elementary characters, and for the mutation theory.

6. The new types were either constant from the beginning, or if weak, inconstant or perishing, showed no tendency to revert

to the parent type, and their constancy or fixity might not be increased by artificial selection.

7. More than one mutant might arise simultaneously from the parent individuals.

8. Any one of the several mutants observed might originate from several parent individuals simultaneously.

9. The mutant forms might arise from successive generations of the parent types.

10. The mutant forms might in turn give rise to new types after their separation from the parent type.

The above statements rest directly upon observations of carefully conducted experimental cultures and admit of but little argument as to interpretation. With this positive evidence at hand questions at once arise as to the frequency, occurrence, prevalence, exclusiveness, and as to the mechanism of discontinuous variation as a method of origin of new species. When we take up these points we at once enter a field of speculation in which it may be seen there is opportunity for unlimited argument, and in which with the bias to which most of us are subject as a result of our training and investigations, it is difficult to maintain a purely judicial attitude. It will be profitable to recall some of the more important facts bearing upon these matters however.

First, as to the occurrence of discontinuous variations in plants the following examples cited by Korschinsky will be illustrative: *Erythrina crista galli* was introduced into cultivation in 1771 and no aberrant forms were seen until seventy-three years later: *Begonia semperflorens* showed deviating forms only after fifty years: *Cyclamen persicum* gave no unusual forms until after one hundred and twenty years of observation: no mutations were observed in *Ipomoea purpurea* in one hundred and twenty years.

De Vries observed many thousands of individuals of a hundred species growing in the vicinity of Amsterdam in 1886 and 1887 and found mutations in only one, that one *Œnothera lamarckiana*. He points out that remains of plants of various species found in mummy cases four thousand years old have been found identical with living species in all recognizable characters. As a result of a rough examination he also concludes that the elementary characters of any species of a higher plant may be reckoned at a few thousand — about 6000 in Œnothera. If Lord Kelvin's estimate of the period during which life has existed on the earth is accepted it might be concluded that in a general way the average interval separating mutable periods of any plant must be several thousand years, although nothing in the nature of the question may be taken to indicate anything like uniformity in the matter. Some writers have put forward the conclusion that at least ten times the above named period, or twenty-five hundred million years, would be necessary for the derivation of the existing forms of plants and animals by natural selection. It must be admitted that both ideas are valuable chiefly as attractive examples of imaginative grasp rather than as affording any real evidence in the matter.

It will be recalled that the various theories which have been put forward to account for the origin of species have been held by their authors and advocates to be mutually exclusive, and it seems to have been, and is still taken for granted by the majority of writers, that all organic forms, both plants and animals, have arisen in the main by one simple method of biological procedure. The development of biological science has certainly reached a stage where this a priori generalization may well be abandoned. I can not say that a candid review of the mechanism of protoplasm, or of the pertinent evidence, from any point of view compels adherence to this ancient assumption.

The great amount of critical study that is being directed to the study of hybrids and hybridization is widening the horizon of this subject momentarily, and the result of our recently acquired information leads us to conclude that species may originate by crossing. In such instances the new types are due either to new combinations of unit characters or to reversionary qualities, it being necessary to keep in mind the fact that by such union of two types no new characters are brought into existence. It must be regarded as unsafe moreover to declare any plant a hybrid of any other given forms unless the process of origin has been carefully followed. The fact remains that hybridization is a demonstrated source of origin of species however, and it is becoming more and more generally recognized that more than one method of procedure may have been followed in the development of the prevalent types of vegetal organism. This view of the subject has been thoroughly discussed by von Wettstein and need not occupy our attention further at the present time (*Bericht, deut. Bot. Gesell.*, Bd. 13, p. 303, 1895).

DeVries concedes that species might originate by more than one method, but he holds that natural selection may account for neither the origin, nor the preservation and continuance of species. He furthermore calls attention to the fact that Darwin repeatedly asserted that characteristics or qualities were formed very slowly but might disappear suddenly, or in other words that retrogressive and digressive species formation might ensue by discontinuous variation or mutation. (*Mutationstheorie.* Bd. 2: 661. 1903.)

It is necessary to point out that the use of the term *natural selection* as applying in any sense to the *origin* of species by mutation is wrong in view of the special meaning long attached to that phrase. Natural selection implies constant and progressive variation in one or many directions, the individuals distinguished by the greatest improvements constituting the fittest and surviving from successive generations. The constant and repeated survival of the fittest and most improved effecting in time such an amount of departure from the original as to constitute a new type. The mutants which arise in discontinuous variability are seen to depart in all directions from the original, but none of these may be fitter than the parent type and may perish. It is probable that many thousands of mutants come into existence for every one that is capable of existence in competition with the parent type. The repeated failure of the successive series of mutants can in nowise affect the character of the later crops of discontinuous derivatives, and hence the failure of the non-fit and the endurance of the improved form are not dependent upon natural selection. Every mutant that survives must not only be suitable for its environment but must be of a structure and habit that will enable it to compete successfully with existing types, in comparison with which it is enormously weaker in numerical strength. It must therefore gain a foothold at once, with but little opportunity for adaptations of any kind. Every mutant is a possible species and the only selection which might be said to act is that which determines the type able to live: this selection has nothing to do with the origin of the surviving form however.

Thus of the sixteen mutants discovered by DeVries one had already established itself when found, although seen to arise anew from the parent type subsequently. Perhaps one or two of the others might have succeeded in gaining a foothold, but the majority of the new forms must have inevitably perished if subjected to the ordinary competition of the prevailing meadow species.

As to the cause of mutation, and the mechanism of the process but little except of a speculative nature may be offered. Korschinsky assumes that heredity and variability are opposing forces or tendencies which are ordinarily balanced. External agencies such as successive seasons of good nutrition might allow the tendency to variation to overcome the hereditary stability and allow the origination of a new form as a result of the unloosed, superfluous unbalanced energy. He supposes that whatever the agencies may be that cooperate to bring about the mutative condition, these forces act upon the developing embryo in the seed, although he hazards no guess at the manner in which this might be accomplished (*Flora*, 89: 240, 1901). The above it may be noted is in direct contrast with the proposal of Darwin that the development of new types is more rapid when species are competing under adverse conditions, or when the struggle for existence is fiercest.

So far as DeVries's theory of mutation is concerned it may be said to be the logical outcome of, and to rest upon his hypothesis of intracellular pangenesis. By this, protoplasm is taken to consist of ideally minute pangens, which make up the living substance. The pangens and aggregations of pangens are the bearers of the elementary characters of the species. Alterations in the numerical relations of pangens are made to account for fluctuating variability. The inactivity of pangens and groups of these units would cause degressive or retrogressive mutation. The formation of new characters in progressive mutations would depend upon the development of new pangens, this process constituting premutation. The formation of identical pangens in separate species would account for parallel mutations.

But little definite evidence is at hand as to the time at which the changes antecedent to mutation, constituting pre-mutation occur, although certain stages of development may be designated, previously to which they must come about. Mutations of the higher plants are first apparent in the seedling but the actual alterations or departure from the hereditary behavior must have taken place at least as far back as the formation of the sexual elements the union of which produced the embryo, and may have occurred even earlier. In any case the mutants are perfectly formed in the embryo and influence of any kind upon the germinating seed may not alter their nature (see page 746). It may be seen from the foregoing that the mutative processes may be connected with either the vegetative body or the sexual elements, and may be found within the sporophyte, or be confined to the gametophyte.

If the pre-mutative alterations occur in the vegetative protoplasts of a self-fertilized individual both gametes would presumably carry the same characters to the union. If, on the other hand, premutation occur in one of the sexual elements, or if it occur in the vegetative cells of species which are cross fertilized only, the embryos formed would be the result of the union of one mutant gamete and one of the regular inherited form. In a sense such mutants might be considered as hybrids. This theoretical aspect of the question seems to find a reflection in the behavior of *Œ. lata*, one of the mutants with pistillate flowers only. When pollinated by the parent form, *Œ. lamarckiana*, it produces *Œ. lata* and *Œ. lamarckiana*.

DeVries conjectures that the causes inducing mutation are partly internal, and partly external to the organism. The state of external factors necessary to the process probably occur only at uncertain intervals, and is supposed to embrace a combination of extremely favorable and unfavorable conditions.

Probably no more profitable subject for research in the whole realm of natural history offers itself to the investigator than the problem of the causes which produce new species. The above supposition deserves early attention from the experimentalist since it is one that is comparatively easily capable of proof and disproof.

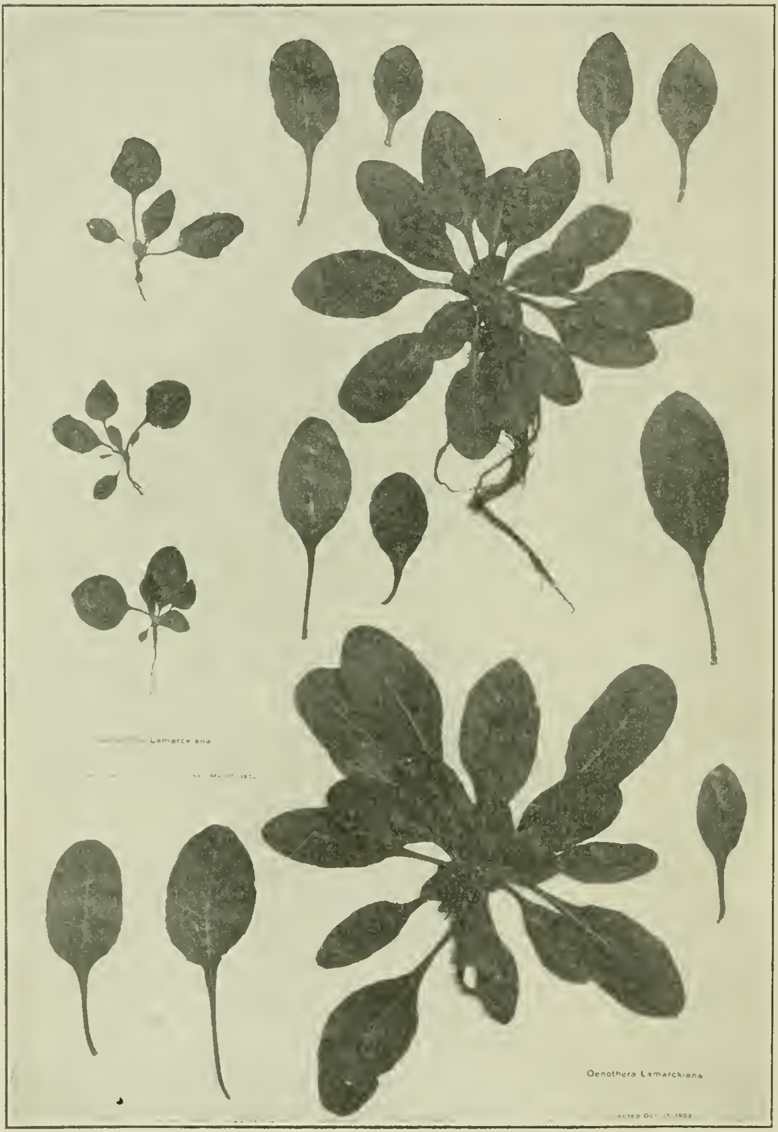
Lamarckiana
Oenothera Lamarckiana

FIG. 1.—*Œnothera lamarckiana.* Rosettes of seedlings two months, and five months of age. Photographed from herbarium sheets. (See Figs. 2 and 3.)

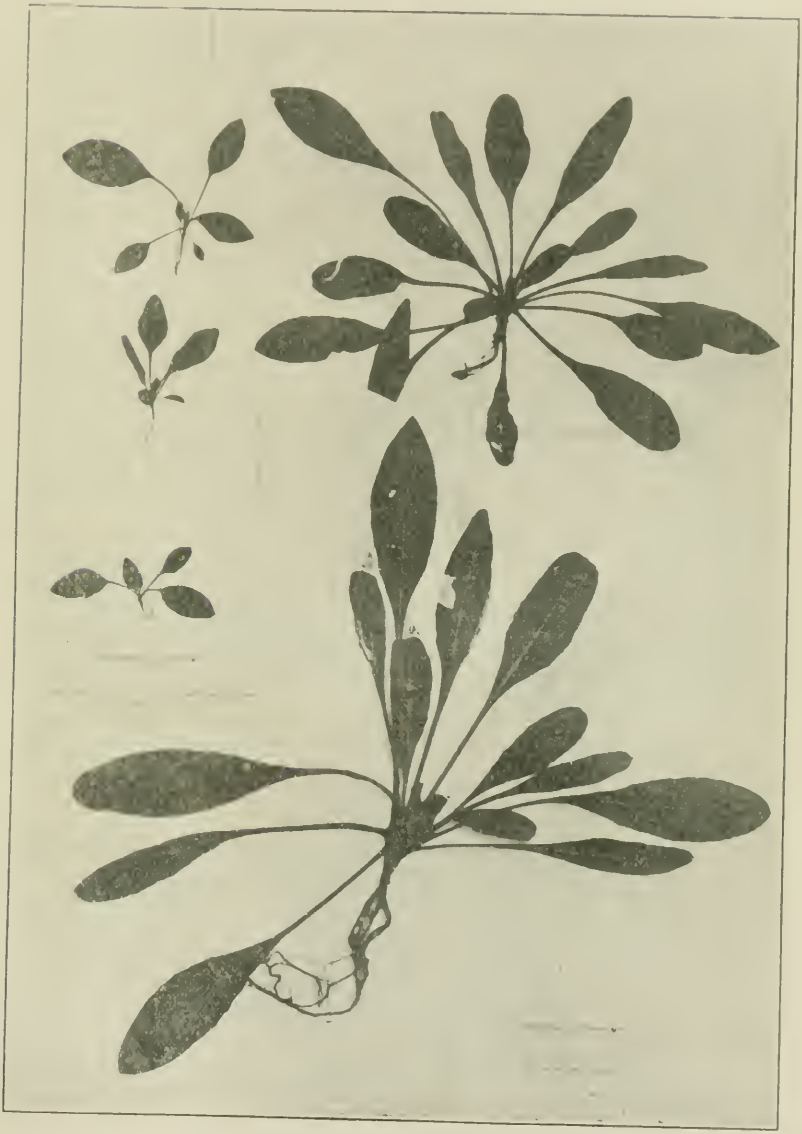

FIG. 2. *Œnothera rubrinervis.* Seedlings two months, and five months of age. Photographed from herbarium sheets. (See Figs. 1 and 3.)

Being desirous of testing the general facts of mutation as illustrated by the behavior of the œnotheras under environmental conditions different from those at Amsterdam, seeds of *Œ. lamarckiana*, *Œ. rubrinervis*, *Œ. lata*, *Œ. nanella*, *Œ. brevistylis*, and *Œ. gigas* were procured from Professor DeVries and these were placed in soil in the propagating houses of the New York Botanical Garden May 15th, 1902. Germination followed in a few days, and a number of individuals ranging from fifteen to forty of every species were pricked out and suitably repotted from time to time. The cultures were examined three to seven times per week except during February, 1902, and July, 1903. The amount of work necessary to make minute and exact observations on all of the above forms being too great a demand upon my time, chief attention was devoted to a comparison of the parent type with *rubrinervis* and *nanella*, two mutant forms.

In order to systematize the results general notes were made continuously upon the habits of the growing plants and formal comparisons were made at successive stages as follows:

First stage.— July 11th, 1902. The plantlets were nearly two months old and still retained the cotyledons.

Second stage.— October 15th, 1902. A distinct tap root had been formed and a rosette of leaves had been developed.

Third stage.— June 1st – 10th, 1903. Adult rosettes had been formed, and the smaller leaves which appear around the base of the stems were apparent. Some flowering stems were beginning to push up.

Fourth stage.— August 10th–15th, 1903. A number of inflorescences had been produced and flowers were opening daily in great profusion on some of the forms. Some of the inflorescences were enclosed in paper bags in order to secure pure seeds by means of artificial transfer of pollen.

The more apparent anatomical differences among the forms examined are shown quite strikingly by the series of photographs and drawings which illustrate this article.

The main fact to be kept in mind in regard to the parent form is that it is a recognized and constant species, which has not undergone noticeable alteration during the long period it has been under exact observation. The seeds from which the

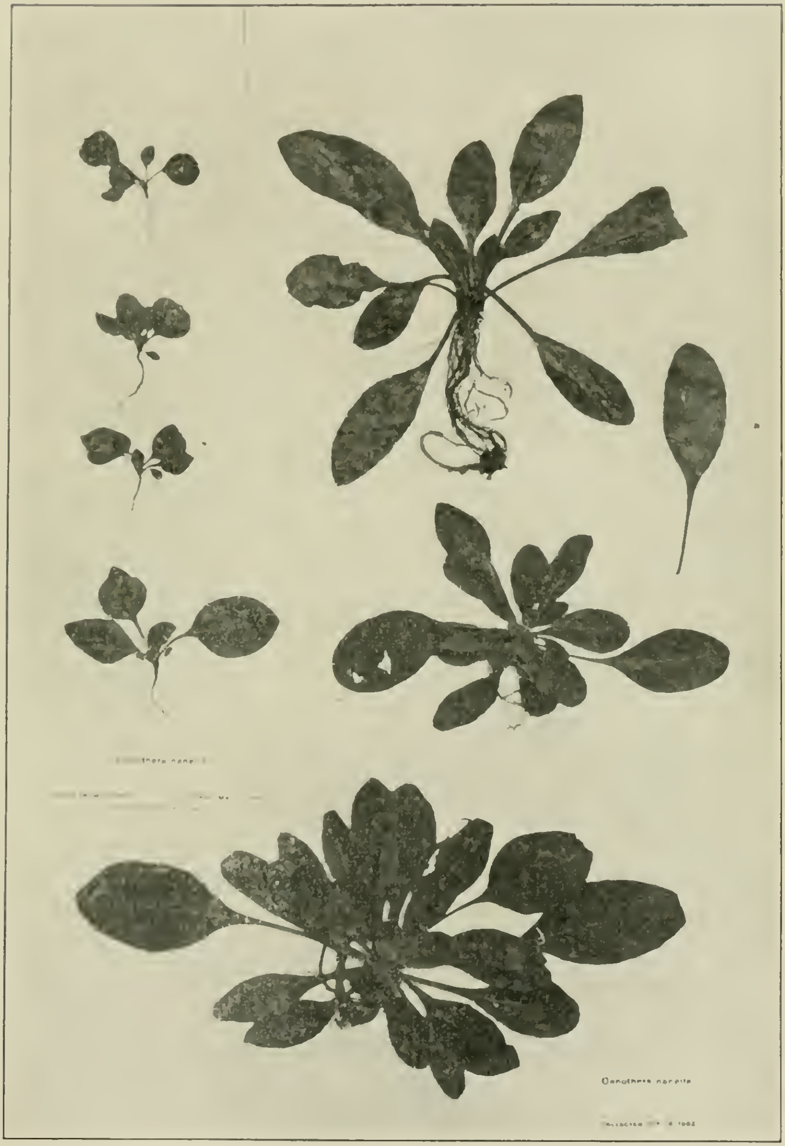
Oenothera nanella

Fig. 3.—*Œnothera nanella.* Rosettes of seedlings two months, and five months of age. Photographed from herbarium sheets. (See Figs. 1 and 2.)

experimental material was derived were sown in a bed at s' Graveland near Amsterdam in 1875 and had been allowed to spread over an adjoining neglected field until in 1884 an area of 2800 square meters was covered. This material showed the presence of a form so different from the parent type, when examined by deVries in 1886, as to lead him to consider it as a new species, and this mutant, *Œ. brevistylis*, which did not arise again during the observations, maintained itself in the same locality during a period of twelve years, records of it having been made as late as 1898, and it is still cultivated among the other mutants grown by deVries and myself. Other forms appeared during the course of the next fourteen years as has been described in detail.

It was deemed advisable to make independent comparisons of the plants grown in my own cultures with the type specimen with which deVries identified his parent form, and to this end Miss A. M. Vail made a visit to the herbarium of the Muséum d' Histoire Naturelle in Paris, in May, 1903, at my request, and also later a journey to Amsterdam and inspected the cultures of *Œnothera* under Professor deVries's own guidance. Miss Vail has kindly prepared the following report on the matter:

"The parent form, *Œnothera lamarckiana* Ser. was found by deVries to agree in every particular with two specimens in the Muséum d'Histoire Naturelle in Paris. These specimens consist of, first: a plant cultivated in the Paris Garden that had formed the basis of the original description of *Œnothera grandiflora* Lam. It bears a label indicating it as having been included in the herbarium of Lamarck which was acquired by the Museum in 1850. On the margin of the sheet in the handwriting of Poiret (the author of the section dealing with *Œnothera* in Lamarck's Encyclopedia) is the following inscription 'Œnothera—(grandiflora)—nova spec. flores magni lutei, odore grato, caulis 3 pedalis.' This specimen is in flower only and consists merely of the branched upper portion of the shoot with numerous rather small leaves and conspicuously large typical flowers. The second specimen comes from the collection of Abbé Pourret that was contained in the collections of Dr.

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[1] For a brief general account of the experimental cultures, see MacDougal, The Original of Species by Mutation. *Torreya*, Vol 2, pp. 65–68, 81–84, 97–100, 1902.

Barbier inherited by the Museum in 1847. It is filed in a cover with *Œ. biennis* L., and bears that name on the sheet, a small label inscribed with a series of prelinnean names, and another with '*Onagra vulgaris* Spach' and '*Œnothera biennis* Linné,' both apparently in Spach's handwriting. This is the plant referred to by de Vries as having been collected presumably by Abbé Pourret in the Paris Garden during his visit in 1788. The specimen represents an unbranched upper portion of a shoot with numerous large well-developed leaves, partly mature capsules and several flowers that are somewhat smaller than those of the previously mentioned specimen. These two specimens differ in no important particular. Tracings of them compared with living plants grown in the New York Botanical Garden from seeds sent by de Vries agree quite perfectly.

"A search through the herbarium of the Muséum d'Histoire Naturelle and that of the New York Botanical Garden does not bring to light any specimen of a wild North American plant that can be referred to *Œ. lamarckiana* as it is now known and cultivated in Europe, nor does it seem to be known to collectors in North America at the present day.

"Several specimens were found however, which might be conjectured as representing a North American plant from which *Œ. lamarckiana* might have been derived. One of them is a plant collected by Michaux now preserved in the Muséum at Paris, and cited by de Vries in the Mutationsteorie (Bd. 1: p. 316) and referred by him to a plant frequently cultivated in Europe under the name of *Œnothera grandiflora* Ait *Œ. suaveolens* Desf. but which he considers different from *Œ. lamarckiana*. A tracing was also made of this plant which consists of two specimens fastened on the same sheet upon which numerous inscriptions bear witness to much diversity of opinion as to its real identity. A small slip of paper bears in Michaux's handwriting '*Œnothera grandiflora*,' another (the customary label of the Michauxian specimens) the inscription '*Œnothera grandiflora* Poiret Encycl.,' in the writing of that author of the section dealing with *Œnothera* in Lamarck's Encyclopedia; beneath that '*Œnothera suaveolens* Hort. par.' in the writing of Desfontaines, and lastly '*Onagra vulgaris grandiflora* Spach.'

in the writing of Spach. The larger of the two specimens consists of a simple entire plant not fully developed, showing root, leaves, flowers, and capsules, but no basal leaves. The other specimen, which is smaller, is incomplete and fragmentary. A comparison of the tracing of the larger specimen with material in the herbarium of the New York Botanical Garden shows that it is identical with a specimen under the name of *Onagra biennis grandiflora* (Ait) Lindl., collected by E. S. and Mrs. Steel on Stony Man Mountain, Luray, Virginia, August 15th, 1901. The comparison also shows that the wild plant has undergone no change of any kind during a period of over a century.

" The following memoranda and citations may be of interest as throwing some light on the history of *Œ. lamarckiana* previous to 1788.

Linnæus in his Species Plantarum says that *Œnothera biennis* was brought from Virginia in 1614 and was then (1753) common in Europe. In Hortus Cliffortianus (1737) he states on p. 144, that it is a native of Virginia, having been brought from there to Europe 120 years before and was at the time he wrote spontaneous and plentiful in the fields of Holland. In Hortus Upsaliensis (p. 94. 1748) he gives the date of its introduction as 1620, then declared it to be spontaneous in Belgium, Italy, 'Gallia and Germania.' So that from the middle of the 17th century it was generally in cultivation in the botanical and horticultural establishments of Europe.

Referring to some of the prelinnean writers we find that Tournefort in *Inst. rei. herb.*, on p. 302 (1700) enumerates nine species of Onagra, the first four of which only are of interest here, as follows:

(1.) *Onagra latifolia. Lysimachia lutea, corniculata.* C. B. Pin. 245.

(2.) *Onagra latifolia, flore dilutiore. Lysimachia corniculata non papposa, Virginiana, major, flore sulphureo.* H. L. Bat.

(3.) *Onagra latifolia, floribus ampliis. Lysimachia Virginiana, altera, foliis latioribus, floribus luteis, majoribus. Cat. Altdorf.*

(4.) *Onagra angustifolia. Lysimachia angustifolia, Canadensis, corniculata* H. R. Par. *Lysimachia corniculata, lutea, Canadensis minor, seu angustifolia* Mor. H. R. Bles.

In the first of these references Caspar Bauhin in *Pinax* on p. 245 (1671) writes of an American evening primrose under the name of *Lysimachia lutea corniculata*, as being a Virginian Lysimachia growing in the Garden at Padua in 1619 and adds that it was a pleasing plant and easy to propagate from seed. The second reference goes back to Hermann's Catalogus, 1687, where on p. 396 he records a species of Virginian *Lysimachia* with sulphur colored flowers as growing in the Garden at Leyden. The third reference is to a plant with larger leaves and larger flowers from the Altdorf Garden. In Jungermann's *Catalogus plantarum quae in horto Medico Altdorphino reperiuntur* we read that a *Lysimachia lutea Fl. majoribus, odore Tabaci.* and a (Lysimachia) *Virginiana lutea Delphinium quorundum*, were known in the old Bavarian garden at Altdorf in 1635 and the statement is again repeated in another *Catalogus* in 1640. It was a sufficiently remarkable plant for Tournefort to note especially in his Institutiones, and it might be inferred that this large flowered plant from Altdorf was the ancestor of *Œnothera lamarckiana*. It would appear as if a form of what is generally claimed to be *Œnothera biennis* L. with delicate sulphureous flowers grew in the Leyden Garden and another with larger flowers in the garden at Altdorf. Under the same name, *Lysimachia corniculata*, an American evening primrose is said to have been growing in the Messina Garden in 1640 and it was known in the Paris Garden at about the same time or a little earlier and in 1653 in the Copenhagen Garden. Morison also records it as occurring in the Hortus Blesensis in 1669. This last reference is the one quoted by Tournefort as his fourth species. Again under the same name of *L. corniculata* Sherard speaks of it on p. 44 of his Schola Botanica as growing in the Paris Garden in 1689 and, presumably, descendents of the plants he saw were those collected by Abbé Pourret a century or so after and later made the type of the much discussed *Œ. grandiflora* Lem. = *Œ. lamarckiana* Ser. The plant described by Linnæus in the Species Plantarum was doubtless a composite species and it would be particularly interesting in this connection to know just what he meant by the plant described in the *Hortus Cliffortianus* as being plentiful in the fields of Holland. A tracing of the specimen which could be considered as the type of the plant described by him in the Hortus Cliffortianus has been kindly furnished by Dr. A. B. Rendle of the British Museum, and although the flowers are somewhat smaller than those of the living plants of *Œ. lamarckiana* as grown in the New York Botanical Garden nurseries, yet the general characters are identical, notably that of the entire or slightly emarginate petals. This character is certainly not typical of the wild weed-like *Œ. biennis* of waste lands in North America to-day. In any case it seems extremely doubtful that all these cultivated evening primroses should be referred to so ungainly and unornamental a plant as *Œ. biennis*.

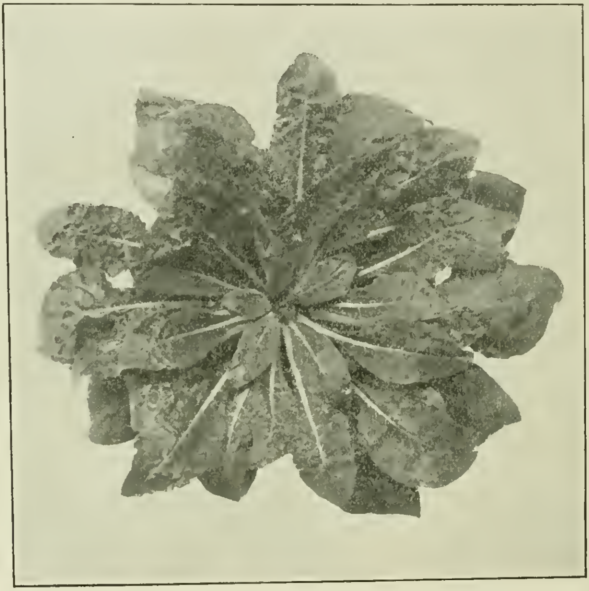

Fig. 4.—*Œnothera lamarckiana*. Adult rosette immediately preceding development of flowering stem. Photograph of living plant taken from directly above. (See Figs. 5 and 6.)

Prof. deVries in an article on the introduction of *Œ. lamarckiana* in Holland (Ned. Kruidk. Arch. ser. 2, Vol. 6, p. 579, 1895) gives a long and detailed history of the ancestors of the plants taken into cultivation for his experiments. They were traced to plants escaped from cultivation and originally raised from seed received from a seedsman of Erfurt, Germany. Prof.

deVries also states that *Œ. biennis* and *Œ. muricata* are found in Holland, notably on the dunes.

It seems well established that a large flowered Œnothera was seen in the Altdorf Garden in 1635, which is probably referable to none other than *lamarckiana*. Later notes of its occurrence are in existence, but the first definite record of the species was in 1788. It has been found constant since this date, both in gardens and when running wild: its evolutionary procedure is therefore none the less valuable as scientific evidence than as if it were an indigenous wild growing species.

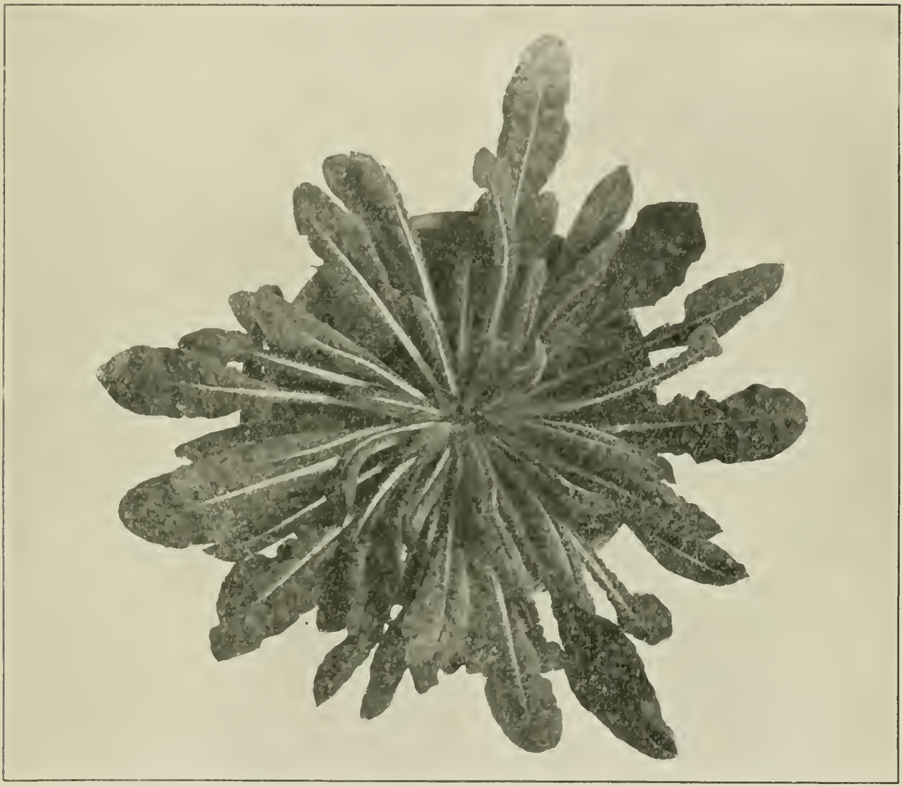

FIG. 5.—*Œnothera rubrinervis*. Adult rosette immediately preceding the development of the flowering stem. Photograph of living plant taken from directly above. (See Figs. 4 and 6.)

Œnothera lamarckiana is a species which, so far as present knowledge is concerned, has no exact duplicate in the native flora of any region, and two probabilities are suggested as to its origin: It may have been a native of a restricted range in "Virginia" in which it has been exterminated by agricultural operations, and hence cannot be found at the present time: or it may have arisen by some such sudden, and abrupt, discontinous variation, as that by which deVries' mutants came into existence, from *Œ. biennis* in the gardens, at Padua, Altdorf or elsewhere: at least no intermediate forms are known."

Only eleven specimens of hybrid seedlings derived from *Œnothera lata* were brought to the adult stage, in my cultures and of these but two conformed to the type of *Œ. lata*, the remainder being the *O. lamarckiana* form. *Œ. lata* does not perfect its stamens but it is capable of being pollinated from the parent. The offspring followed the laws governing parent and mutant hybrids, which with deVries were found to consist of 18% to 20% of the mutant type and the remainder of the parent. My own results agree with this. It is clear that this form would not have survived beyond the season of its appearance as it does not display any marked propagative capacity.

Œnothera nanella originated in deVries's cultures in 1888 and has since been followed by him through fifteen seasons. The qualities of this form separate it from the parent in such manner that it might be considered as a variety by some systematists, although its behavior and physiological properties are constant and very clearly distinguishable. In following out the development of the plant during the eighteen months over which my own observations extended it became evident that it differs most widely from the parent in its earlier, and also in its adult stages, being most like it in the full rosette stage. The most apparent feature is its diminutive size, both in the young plant and in the mature flowering shoot. The stem shows but little capacity for branching and did not reach a height of more than 20 to 25 cm. in my cultures, or about one fourth that of the parent, which sends out numerous vigorous branches. The first few leaves have very broad laminæ with irregular apical portions, and are short petioled. Later leaves are more nearly like the parent type but remain shorter petioled which has the effect of making a denser more crowded rosette. The bases of the lamina are almost cordate in some instances, and vary from oblong ovate to ovate in outline, being sparingly toothed. The plants established in the soil in the open air did not bloom until about three weeks later than the parent and *Œ. rubrinervis.* No noticeable departure from the characteristics assigned this form by deVries was found.

Seedlings of *Œnothera rubrinervis* were seen to have narrower leaves throughout from the earliest stages. The rosettes were very closely appressed to the soil, and in this stage the margins of the long petiolate leaves were inrolled, thus decreasing their apparent width. Attention is to be called here to the fact that comparisons of leaf forms in plants of this kind are permissible only between organs on corresponding portions of shoots. The laminæ were more bluntly toothed than those of the parent type, and the midribs occasionally bore a tinge of red, while the entire shoot including the leaves of the upper part of the stem showed a tendency to the formation of anthocyan. The physical qualities of the leaf were strikingly different from those of the parent, perhaps the most noticeable feature being the great brittleness of the leaves and stems of

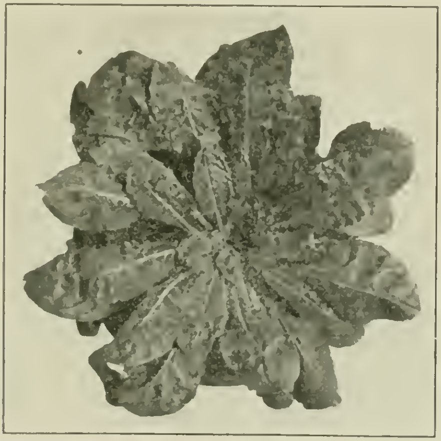

FIG. 6.—*Œnothera nanella.* Adult rosette immediately preceding the formation of flowering stem. Photograph of living plant taken from directly above. (See Figs. 4 and 5.)

young plants, indicative of high turgidity and weak development of mechanical and supporting tissues. Both of these characters have been observed by deVries, who notes that the bundles of bast fibers of the flowering stems were composed of elements with thinner walls than those of the parent type.

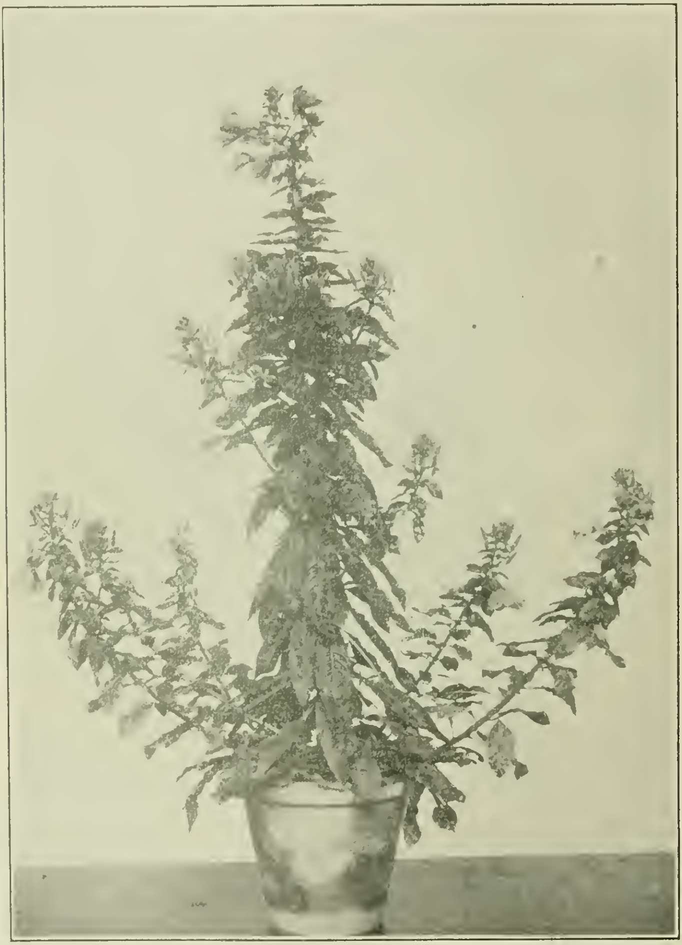

FIG. 7.—*Œnothera lamarckiana.* Adult plant two weeks after beginning of opening of flowers. Photograph of living plant grown in the soil in the open air, and temporarily fixed in a pot. (See Fig. 8.)

The leaves of the full rosettes, were silvery white owing to the fact that the hairs on both surfaces were both longer and more numerous than on the parent type. The average length of the hairs on the upper surfaces was 35 as compared to 28 in the parent type, and on the lower surfaces 42 as compared to 30. The average number of stomata on a unit of area of the upper surface of the leaves of *rubrinervis* was 37 as compared with 34 in *Œnothera lamarckiana*. The brittleness characteristic of the tissues of *rubrinervis* may be seen to extend even to the hairs, since these structures are easily detachable from the dried specimens, and hence giving rise to the conclusion that *rubrinervis* is less densely pubescent than *lamarckiana* as given in the systematic description below.

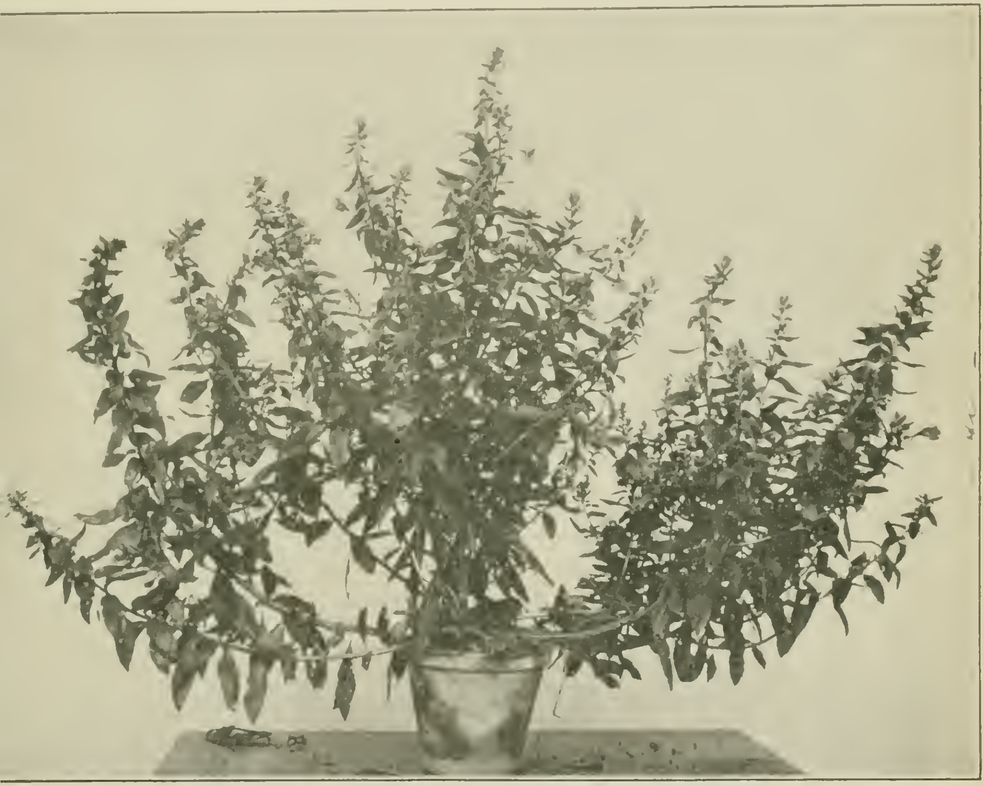

Fig. 8.—*Œnothera rubrinervis.* Adult plant two weeks after beginning of opening of flowers. Photograph of living plant grown in the soil in the open air, and temporarily fixed in a pot. (See Fig. 7.)

Still another major difference between the forms in general habit is that of the method of branching and the growth of the branches. In *Œ. lamarckiana*, the branches from the basal portion of the shoot were of a length amounting to more than half that of the shoot which is also true of *Œ. rubrinervis*. The upper branches of the former remain short and stout however, while those of *rubrinervis* attain greater lengths which decrease upwardly so that a plant may have a roughly globular outline.

The majority of the features in which the mutant departs from the parent, as described above, are of a nature that would equip the new form for living under more arid conditions than the parent, although the actual endurance of *rubrinervis* to decreased supply of moisture was not tested. So far as this single observation goes then, it is to be seen that the new characters of mutants are harmonious in their adaptive relations.

Œnothera rubrinervis originated in deVries' cultures in 1899, and has also appeared by independent mutations since that time. It has been found to be independent and self-maintenant in competition with the parent form.

A large number of flower buds in both *rubrinervis* and *lamarckiana* were pierced by some insect, and the larvæ coming from the eggs deposited made great destruction, and also caused the abnormal enlargement of the buds and capsules, which failed to perfect seeds.

De Vries has continued to find the recurrence of some of the mutants in the successive crops of seedlings of *Œnothera lamarckiana* indicative of the fact that the mutating period of the parent has not yet been passed. No departures from the parent type were found among the individuals which have come into bloom up to this time in the New York Botanical Garden.

The leaves of the seedlings of *Œ. lamarckiana* are easily distinguishable from those of *lata*, *nanella*, and *rubrinervis* even in the earlier stages, although not so easily separable from some of the other forms such as *brevistylis* and *leptocarpa* according to deVries. The earliest leaves were ovate, or round-ovate with rounded apices, or sometimes slightly pointed. These leaves as well as those formed at the age of five months were distinctly petiolate but with the laminæ relatively narrower. Adult basal leaves of the rosette in the period immediately preceding flowering were petiolate with the apices bluntly pointed and with broad laminæ. The margins of all of the earlier leaves were sparingly but sharply toothed.

Plants set out early in May were blooming profusely early in August. The basal branches coming out from the axils in or near the rosettes were strong and vigorous but the upper branches of the stem were short and offered a distinct contrast to the longer, more slender branches of *rubrinervis*, with which it was also contrasted by its denser foliage and larger more showy flowers. Both stems and branches were thicker and heavier than in *rubrinervis*.

After noting the great variance in behavior and appearance of the parent and two mutants as described above, mature plants in bloom, the dried material of the younger plants, and photographs were submitted to Dr. J. K. Small, who had previously published an arrangement of the American species, and who is familiar with them in (Small, J. K. Œnothera and its Segregates. Bull. Torr. Bot. Club. 23: 167–194, 1896.) the herbarium and in the field. Dr. Small has kindly prepared the following statement concerning three forms, which is given in full below:

The characteristics of *Œnothera lamarckiana* and *Œ. rubrinervis* as given by Dr. Small are set in parallel columns for convenience of comparison:

Oenothera lamarckiana Ser.

I. *Seedling about two months old.*— Leaves sparingly pubescent; blades ovate to suborbicular, the larger about 2 cm. wide, obtuse or rounded at the apex, each abruptly narrowed into a petiole.

II. *Seedlings 5 months old.*— Rosettes relatively dense: leaves copiously fine-pubescent; blades typically oblong, the larger ones fully 3 cm. wide, quite approximately denticulate, obtuse, or somewhat apiculate at the apex, much longer than the petioles.

III. *Adult plant.*— Plant very stout and luxuriant, 0.5 to 1 m. tall. Stem markedly channeled, sparingly hirsute with rather spreading hairs, nearly simple, or with several relatively short ascending branches near the base, and few very short ones above: leaves very numerous, 2–2.5 dm. long about the base of the stem; blades shallowly and often irregularly toothed, those of the lower cauline leaves broadly spatulate to oblong, rather acute, each narrowed into a nearly semi-terete petiole, those of the upper cauline leaves oblong to oblong lanceolate, acute, or somewhat acuminate, short-petioled: bracts subcordate at the base: hypanthium 4.5–5.5 cm. long, about 8 mm. wide at the mouth, prominently ridged: sepals 4–5 cm. long, longer than the tubular portion of the hypanthium, the free tips 8–10 mm. long: petals firm 4–5 cm. long, emarginate: anthers 13–15 mm. long: stigmas 5–6.5 mm. long. (See Figs. 1, 4, 7 and 9.)

Oenothera rubrinervis deVries.

I. *Seedlings about 2 months old.* — Leaves manifestly less pubescent than those of *Oe. Lamarckiana*; blades elliptic, the larger ones about 1.5 cm. wide, acute or acutish at the apex, each gradually narrowed into a petiole.

II. *Seedlings 5 months old.*— Rosettes lax: leaves less densely pubescent than in *Oe. Lamarckiana*; blades spatulate to elliptic-spatulate or oblong-spatulate, the larger ones about 2.5. cm. wide, remotely denticulate, acute, or abruptly pointed at the apex, about as long as the petioles or shorter.

III. *Adult plant.*— Plant relatively stout, less luxuriant than *Oe. Lamarckiana*. Stem scarcely channeled, hirsute, with rather ascending hairs, typically branched throughout, the branches near the base elongated, decumbent, the upper ones gradually shorter: leaves numerous; blades less prominently toothed than in *Oe. Lamarckiana*, those of the lower cauline leaves spatulate to broadly oblong, obtuse or acutish, each narrowed into a relatively long petiole, those of the upper cauline leaves elliptic-oblong to oblong or oblong-lanceolate, acuminate, short-petioled: bracts rounded or round-truncate at the base: hypanthium 5.5 to 6 cm. long, about 4 mm. wide at the mouth, obscurely ridged: sepals 3.3 to 3.5 cm. long, shorter than the tubular portion of the hypanthium, the free tips 5–6 mm. long: petals tender, 3–3.5 cm. long, notched: anthers 6–10 mm. long. stigmas 7.5–10 mm. long. (See Figs. 2, 5, 8 and 10.)

Œnothera nanella was taken by deVries to have a degree of separation from the parent type that would lead it to be considered as a variety, a conclusion which is borne out by Dr. Small's description as given below:

I. *Seedling about two months old.* — Resembles that of *Œnothera lamarckiana*; but the leaf-blades are less uniform, some of them ovate or oval, others ovate and somewhat lobed near the apex, others broadly ovate, or prominently apiculate.

II. *Seedling 5 months old.*— Nearly like that of *Œ. lamarckiana*; but leaves inclined to have longer petioles.

III. *Adult plant.*— Plant, stout and stocky in all parts, resembling *Œ. lamarckiana*, but smaller, less than 3 dm. tall. Stem obscurely channeled, hirsute with somewhat ascending hairs, simple: leaves approximate, 7–12, 5 cm. long near the base of the stem; blades shallowly, often rather remotely, but quite evenly toothed, those of the lower cauline leaves spatulate to oblong, acute, or acutish, each narrowed into a semi-terete petiole, those of the upper cauline leaves broadly oblong to oblong-ovate, acute or slightly acuminate, nearly sessile: bracts subcordate at the base: hypanthium 3–3.5 cm. long, about 5 mm. wide at the mouth, obscurely ridged: sepals 3–3.5 cm. long, longer than the tubular portion of the hypanthium, the free tips 5–6 mm. long: petals 3.5–4 cm. long, emarginate: anthers 11–12 mm. long: stigmas 4–5 mm. long.

GENERAL SUMMARY.

Discontinuous variation as a possible method of origin of species was considered by Charles Darwin in his studies of plants and animals under domestication, and he concluded that if new forms did arise in this way that they were not self-maintenant (1868). On the other hand Galton took the position that the evolution of species is not necessarily by minute steps (1889), but Dollo (according to deVries's, *Mutationstheorie*, Bd. 1, p. 46, 1901) was the first to accept discontinuous variation as the prevalent method of origin of species (1893). Bateson (1894) brought together a large amount of evidence as to types which have arisen in this manner, and a comprehensive summary of

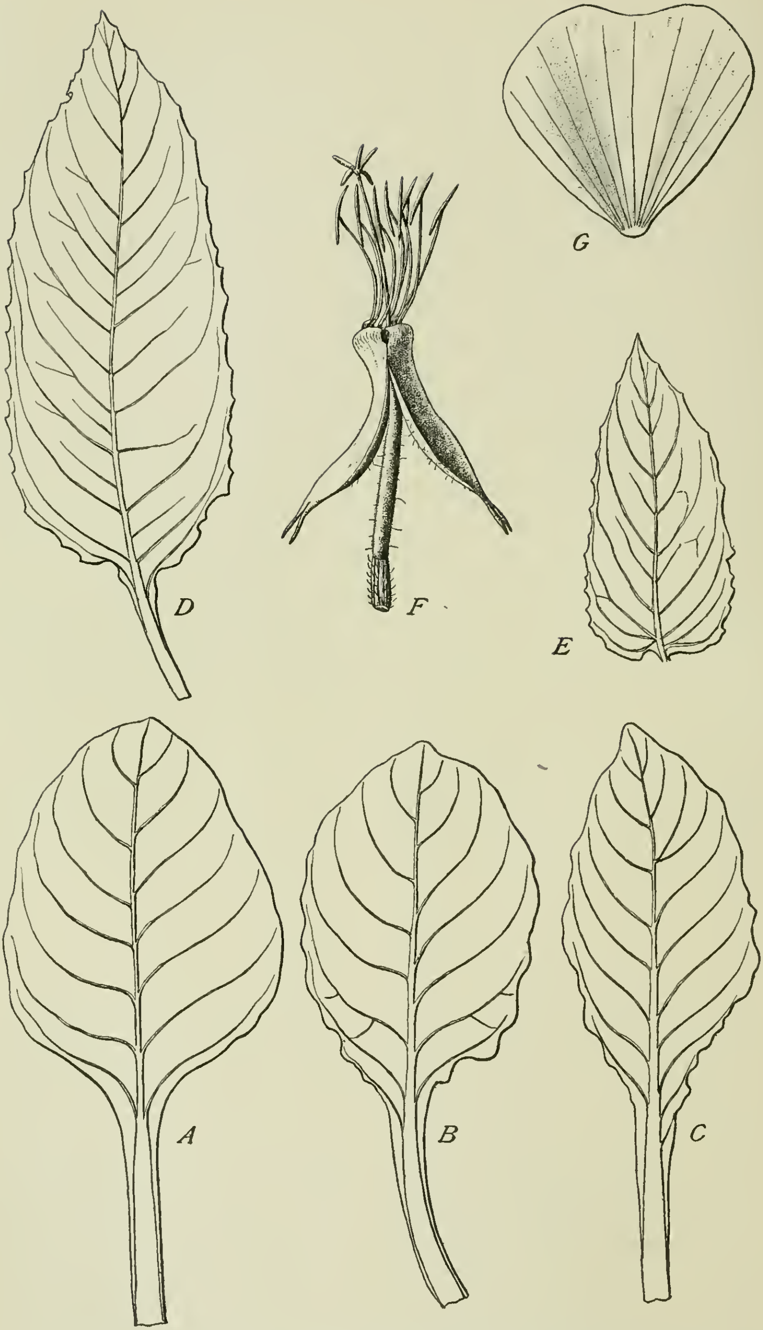

Fig. 9.—*Œnothera lamarckiana*. *A*, leaf from basal portion of adult rosette; *B*, leaf from middle, and *C*, leaf from upper portion of rosette; *D*, leaf from middle of flowering stem; *E*, bract from lower part of inflorescence; *F*, flower with petals removed; *G*, petal. (See Fig. 10.)

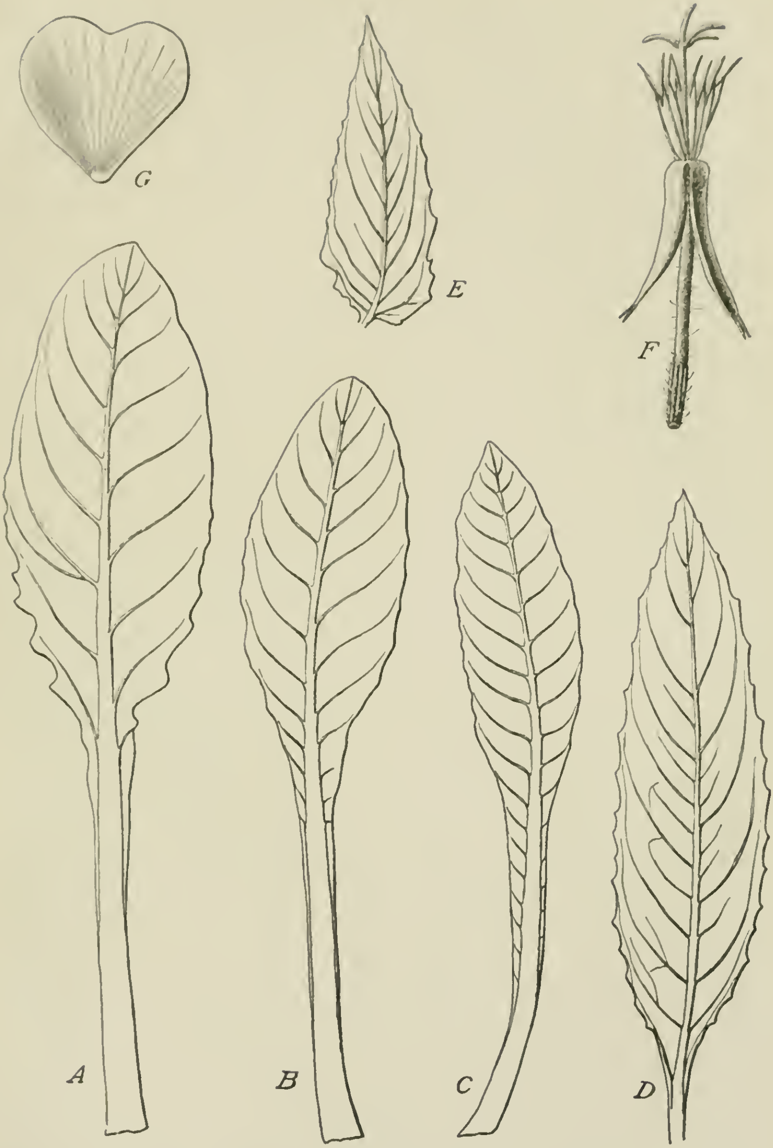

Fig. 10.—*Œnothera rubrinervis.* *A*, leaf from lower part of adult rosette; *B*, leaf from middle portion, and *C*, leaf from upper portion of rosette; *D*, leaf from middle of flowering stem; *E*, bract from lower part of inflorescence; *F*, flower with petals removed; *G*, petal. (See Fig. 9.)

the principal evidence furnished by plants was made by Korschinsky in 1899. Systematic observations upon the subject were begun by deVries in 1886 and have been continued until the present time. As a result of his investigations deVries formulated his "Mutationstheorie," which has appeared in book form, the separate parts of which have been published in the period of 1901–1903. This hypothesis rests upon the theory of pangenesis previously formulated by him.

The parent type, *O. lamarckiana*, from which deVries saw mutant forms arise has been found constant in its characters in cultivation in Europe and America and also when running wild. This type is not identical with any known member of the American flora, and is most nearly allied to *Onagra biennis grandiflora* (*Oenothera biennis grandiflora*) from which it is suggested it might have arisen by mutation.

The mutant derivatives of the parent form are found to be constant in their characters, with no connecting or intergrading forms, as illustrated by the cultures of the parent, *Œ. nanella* and *Œ. rubrinervis*, in the New York Botanical Garden during 1902–1903. The mutants are clearly separable from the parent and from each other both by physiological and taxonomic standards. Furthermore the specific character of the mutants was borne out by their behavior when hybridized with one another.

It has become evident from the results so far accomplished that the testing, study, proof or disproof of the theory of the origin of species by mutation involves an actual examination of lines of descent, and observations upon successive generations of organisms of known genesis. In this manner only may mutant forms be distinguished from hybrids, individuals with aberrant non-transmissible characters and teratological formations. The nature of the questions involved, and the essentially material character of the evidence to be considered is such that all controversial discussions not supported by facts of this character must be viewed with distrust. In no instance is this more plainly apparent than in the recent treatment of the subject by Vernon (Vernon, H. M. *Variation in Animals and Plants.* 1903). This author says "Hence it (*Œnothera lamarckiana*) is probably a garden variety of *Œnothera biennis* (Evening Primrose), and may be a hybrid plant, whilst the mutations obtained by deVries may be merely partial or complete reversions to the original ancestors of the plant." It is quite possible, and even probable that *Œ. lamarckiana* may have been originally derived from the same type as *Œ. biennis* as noted above, but to designate it as a "garden variety," and as such ineligible as research material is simple evasion. The plant in question has been under more or less continuous observation for a hundred and fifteen years during which period it has been constant in its characters, and has shown no evidence by anatomical similarity or physiological behavior of being anything but an independent species. With what species could *biennis* hybridize to produce *lamarckiana*? The genus comprises a comparatively small number of types, all natives of America, and none of which were available as a hybrid mate to *biennis* at the time of the origin of *lamarckiana*. The conjecture in question is totally unsupported after the most rigid search for evidence upon the matter.

Again to consider the mutants as reversions to the original ancestors of *lamarckiana* is impossible, since the mutant forms exhibit qualities not possessed by any other known members of the genus, including *biennis*.

The point raised by Bateson and Saunders (Reports to the Evolution Committee. Royal Society. I. p. 153, London, 1902) that the pollen of *lamarckiana* contains deformed grains, which points to its origin by crossing, is without significance, since the author has found that the stamens of plants of *biennis* growing in the vicinity of New York exhibit a much larger proportion of deformed pollen than that of the specimens of *lamarckiana* cultivated in the New York Botanical Garden.

It has been impossible so far to assign mutations to definite causes, or to forecast the frequency, or occurrence of the phenomenon. These phases of the subject constitute the most important problems of the subject, which await investigation. Theoretical evidence upon such a subject can have but limited value, and conclusions of any satisfactory degree of finality may be expected only from direct experimental research under circumstances in which the probability of error is reduced to a minimum.

So far as the origin of mutations is concerned, it seems well decided that the premutative alterations in seed-plants ensue in the vegetative and sexual cells previously to the formation of the embryo in which they first appear, and that no environmental disturbances may bring about the alterations in question by direct action on the seedling.

It is not the purpose of this paper to discuss the various theories which have been put forward from time to time to account for the origin of species, but to bring under consideration the facts upon which the conclusions as to the origin of species by discontinuous variation have been based by deVries. These facts make inevitable the conclusion that new types of specific rank, taxonomically separable, and physiologically distinct and constant, without intergrading and connecting forms, have arisen in Œnothera by discontinuous variation. That mutation is the principal method of evolutionary procedure is not proven. That natural selection is universally prevalent is certainly disproven: that natural selection or any other method is capable of accounting for the existence of any single species has not been proven with the finality offered by the evidence of discontinuous variation. It may be said, therefore, that species have actually been demonstrated to have arisen by mutation, some are known to have arisen as the result of hybridization, and that evidence has been accumulated which has been interpreted to demonstrate the origin of species by natural selection, and by adaptation. Nothing in the nature of living organisms demands that all species should have originated in the same manner, or that one simple, or single method of procedure should have been followed.

New York Botanical Garden.
August, 1903.

CONTRIBUTIONS FROM THE NEW YORK BOTANICAL
GARDEN—No. 49

THE POLYPORACEAE OF NORTH AMERICA—VI.
THE GENUS POLYPORUS

By WILLIAM ALPHONSO MURRILL

NEW YORK
1904

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The Polyporaceae of North America — VI. The genus Polyporus

William Alphonso Murrill

The genus *Polyporus*, as established by Micheli (Nov. Pl. Gen. 129. *pl. 70–71.* 1729), was such a natural division and so clearly distinguished that it remained intact for over a century. Its nomenclatorial type was *P. leptocephalus* (Jacq.) Fr. and associated with this species were some of the most common and well-known members of the family. Unfortunately, however, Linnaeus retained the name *Boletus* for all pore-bearing fungi, and those mycologists who adopted Micheli's genus failed to establish it according to modern ideas. Adanson, for example, only cited Micheli's figures and listed no properly named species; Haller used only polynomials; and Scopoli in his *Introductio* listed no species at all under *Polyporus.* It was thus left to Paulet (Icon. Champ. *pl. 13.* 1793) to securely establish the genus. Paulet's work, written twenty or more years before its publication, contains descriptions and figures of six species of *Polyporus; P. Ulmi, P. frondosus, P. umbilicatus, P. carbonarius, P. fasciatus* and *P. Tuberaster*, four of which belong to Micheli's genus in the strictest sense. The first species, *P. Ulmi*, is the very common one well known as *P. squamosus* (Huds.) Fr. and must be considered the nomenclatorial type of *Polyporus* according to principles now in vogue. The general use of *Polyporus* instead of *Boletus* is chiefly due to Fries, who, without knowledge of Paulet's work, "restored" the name in 1815 and made it popular in spite of the influence of Linnaeus.

In recent systems of classification the original significance of the term *Polyporus* has been somewhat perverted. Karsten, for example, assigned *Polyporus* to the terrestrial central-stemmed forms and placed the wood-loving species under the new genus *Polyporellus* (Medd. Soc. Faun. et. Fl. Fenn. **5**: 37. 1879). Quélet adopted new names for both of these groups, *Caloporus* for the first and *Leucoporus* for the second, and erected the monotypic genus *Cerioporus* on *Polyporus caudicinus* (Enchiridion Fungorum, 164–167. 1886). Patouillard followed Quélet in the main, but used *Polyporus* in the Karstenian sense instead of *Caloporus* and proposed the new name *Melanopus* for the group to which Karsten had assigned the name *Polyporellus* (Hymenom. Eur. 137. 1887). One finds, therefore, four modern generic names, *Polyporellus*, *Leucoporus*, *Cerioporus* and *Melanopus*, associated either with the type or with a near ally of the type of the genus *Polyporus* and hence synonymous with it.

The species of this genus are in general very similar in appearance and habit, most of them being small dark-colored plants attached to fallen branches and other decaying wood on or near the ground. One species, however, *P. caudicinus*, is very large and does considerable damage to living trees, especially in Europe where it is abundant. The smallest plant of the genus is *P. Acicula*, a tropical form only two millimeters in diameter represented by a single specimen in the Kew herbarium. Many other species of this group are based upon very scanty collections, some well preserved, others now in poor condition, and most of them inadequately described. The task of the monographer is, therefore, in this case unusually difficult and his results more or less unsatisfactory.

Synopsis of the North American species

1. Stipe pallid or light brown, centrally attached, not darker than the pileus. 2.
Stipe wholly or partly black or fuliginous, variously attached, usually darker than the pileus. 17.

2. Margin of pileus not ciliate. 3.
Margin of pileus ornamented with cilia, which often disappear with age. 12.

3. Pileus beset near the margin with hydnoid processes. 1. *P. hydniceps.*
Pileus plainly villose, tomentose or scabrous, often becoming glabrous with age. 4.
Pileus minutely tomentose or glabrous from the first. 8.

4. Pileus scabrous, irregular, umbrinous, margin involute; stipe scabrous, tubes small, 4 to a mm., dissepiments dentate. 2. *P. scabriceps.*
Pileus villose or tomentose. 5.

5. Pileus becoming virgate from the rupture of the cuticle, tubes 2 to a mm., decurrent, dissepiments dentate. 3. *P. virgatus.*
Pileus not becoming virgate. 6.

6. Pileus less than 2 cm. in diameter, ochraceous, tubes 2 to a mm., decurrent to the base of the stipe. 4. *P. delicatus.*
Pileus more than 2 cm. in diameter. 7.

7. Tubes decurrent, very short, entire, pileus dark purple, ornamented here and there with paler radiating lines, surface finely tomentose, becoming glabrous. 5. *P. dibaphus.*

Tubes not decidedly decurrent, denticulate when mature, pileus yellowish to smoky black, villose, at length glabrous, spores oblong, curved, 6 × 2 μ. 6. *P. Polyporus.*

8. Sporophore goblet-shaped, pileus less than 3 cm. broad, shallowly depressed at the center, stipe long, striate, expanding into the pileus. 7. *P. Tuba.*

Sporophore trumpet-shaped, pileus 5–10 cm. broad, deeply infundibuliform, stipe 3 cm. long, pallid, pulverulent. 8. *P. craterellus.*

Sporophore not as above. 9.

9. Pileus minute, 2 mm. in diameter, umbilicate, margin involute, pores alveolar. 9. *P. Acicula.*

Pileus large, 10 cm. or more in diameter, umbrinous, stipe short, thick, hispid, pores at length sinuous, dissepiments dentate. 10. *P. discoideus.*

Pileus of medium size, 2–5 cm. in diameter. 10.

10. Context whitish or brownish in color, extremely thin. 11.

Context golden-yellow, not extremely thin, tubes remote from the stipe. 11. *P. phaeoxanthus.*

11. Pileus brown, polished, context light brown, tubes decurrent. 12. *P. Columbiensis.*

Pileus white or pallid, more or less translucent, context white, tubes adnate, exceedingly minute, 8 to a mm. 13. *P. obolus.*

12. Tubes alveolar. 13.

Tubes not alveolar. 15.

13. Margin of pileus finely hispid, broadly sterile below, surface ochraceous, radiate-striate, stipe brown, pulverulent. 14. *P. aemulans.*

Margin of pileus strigose, fertile below. 14.

14. Pileus very thin, smooth, pellucid, fragile, stipe thicker below, setulose. 15. *P. arculariellus.*

Pileus not very thin, fuscous-squamulose to glabrous, stipe equal, grooved, squamulose, grayish-fuscous. 16. *P. arcularius.*

15. Tubes fairly regular, stipe slender, not polished, plants rather delicate, cilia variable in form and persistence. 16.

Tubes very irregular, stipe usually thick and polished, pileus tough, umbilicate, yellowish-white with brown marginal band, cilia short, fugacious. 17. *P. variiporus.*

16. Pileus opaque, not translucent, 1–4 cm. in diameter, cilia long, of uncertain duration, plants mostly cespitose. 18. *P. Tricholoma.*

Pileus very thin, more or less translucent, 1–2 cm. in diameter, cilia short, slender fugacious, plants not cespitose. 19. *P. Cowellii.*

17. Pileus squamose, very large, flabelliform, tubes large, alveolar. 20. *P. caudicinus.*

Pileus finely tomentose, drab-colored, with reddish-brown spots, small, circular, tubes rounded, minute. 21. *P. maculosus.*

Pileus glabrous, uniform in color, variable in form, tubes punctiform. 18.

18. Stipe ivory-black below, pileus usually ochraceous, surface scarcely depressed, margin even, not becoming extremely thin. 22. *P. elegans.*
Stipe smoky-black below, pileus usually chestnut-colored, depressed at the center or behind, margin very thin and irregular. 23. *P. fissus.*

1. POLYPORUS HYDNICEPS B. & C. Jour. Linn. Soc. Bot. **10**: 305. 1868

This is one of Wright's plants collected in Cuba. Berkeley's description is characteristically brief, but, fortunately, the type still exists in fairly good condition in the Kew herbarium. It is readily distinguished from all other species in the genus by the short cylindrical or subpyramidal hydnoid processes which it bears on the surface of the pileus near the margin. In shape it is variable and quite irregular, often breaking into fan-shaped lobes as it develops and folding inward or outward at the margin as circumstances determine. The stipe is short, thick, usually blackish and often reticulate. The fruit bodies occur at times in clusters with their stipes closely united at the base. In general appearance this species resembles *Scutiger griseus* and its near allies, but it seems hardly fleshy enough for that group and is moreover so much like species of *Polyporus* in habit that I have retained it in the latter genus as here restricted.

2. POLYPORUS SCABRICEPS B. & C. Jour. Linn. Soc. Bot. **10**: 305. 1868

This species is well named. The type at Kew, collected by Wright in Cuba on decaying wood, is well preserved and still shows the characteristic scabrous covering. Other characters are the dark brown surface, involute margin, decurrent, dentate tubes and short brown stipe. Like most of the Cuban species, it is rare and very imperfectly known as regards distribution and variation.

3. POLYPORUS VIRGATUS B. & C. Jour. Linn. Soc. Bot. **10**: 304. 1868

Six type plants of this species are at Kew, collected in Cuba by Wright. They are of the typical *Polyporus* form and habit with rather delicate, fragile tubes and thin cuticle, which at length ruptures in a way quite characteristic of the species. This plant resembles *P. discoideus*, but is tougher, firmer and somewhat smaller in addition to being virgate.

4. POLYPORUS DELICATUS B. & C. Grevillea, **1** : 37. 1872

Only one small plant of this species is to be found in the Kew herbarium. It was collected in Alabama by Peters, growing on decaying wood. It is uniformly ochraceous in color, tomentose, of soft elastic substance, with a thin undulate revolute margin. The tubes are angular, 2 to a mm., decurrent even to the base and quite collapsed when dry. The stipe is central and radicate, and the buried portion is darker in color than the rest. At first sight, the surface suggests *Polyporus fractipes*, the color being very similar in both, but the central stipe, firmer substance and much larger tubes of *P. delicatus* readily distinguish it from that species.

5. POLYPORUS DIBAPHUS B. & C. Grevillea, **1** : 36. 1872

This plant resembles *P. Polyporus* in many respects, but its pore structure appears to be different. It was collected by Peters in Alabama on trunks of *Ilex*. The type at Kew is the larger share of a single specimen cut in two. A better developed plant might show closer resemblance to *P. Polyporus*. One can never be entirely free from the suspicion that species resting upon a slight material basis and closely resembling species that are common and variable may possibly be only undeveloped or depauperate or abnormal forms of the more abundant species. It seems best, however, in the present instance to consider *P. dibaphus* as distinct until its relationships are more clearly proved.

6. **Polyporus Polyporus** (Retz)

Boletus Polyporus Retz, Vet. Ac. Handl. 253. 1769.

Boletus brumalis Pers. Neues Mag. Bot. **1**: 107. 1794. Batsch, Elench. Fung. *pl. 10*, *f. 42a*. 1783.

Boletus fasciculatus Schrad. Spic. 154. 1794.

Polyporus brumalis Fr. Obs. Myc. **2** : 255. 1818.

Polyporus luridus B. & C. Grevillea, **1** : 37. 1872.

Polyporellus brumalis Karst. Medd. Soc. Faun. et. Fl. Fenn. **5** : 37. 1879.

Polyporellus Polyporus Murrill, Jour. Myc. **9** : 93. 1903.

There are two forms of this widely distributed plant, both occurring throughout Europe and North America. It was the yellow, or vernal, form which Retz described, while Schrader was dealing with the darker autumnal form of the plant. In his synopsis, Persoon separates the two forms as varieties *vernus* and *fasciculatus*. *P. luridus* of Berkeley and Curtis is to be referred to the latter variety.

This species is found on various kinds of decaying wood in forests and groves, usually upon branches lying on the ground. Its persistence far into the winter in the fresh state led Persoon to give it the name by which it is generally known. Among the specimens examined are the following: Tyrol, *Bresadola;* Berlin, *Sydow;* Finland, *Karsten;* Sweden, *Murrill;* Canada, *Dearness*, *Macoun;* Maine, *Ricker;* New Hampshire, *Miss Minns;* Connecticut, *Wright;* New York, *Shear*, *Underwood*, *Overacker;* Delaware, *Commons;* Ohio, *Morgan;* Wisconsin, *Lapham*, *Seymour;* Iowa, *Holway;* Montana, *Anderson.*

7. POLYPORUS TUBA B. & C. Jour. Linn. Soc. Bot. **10**: 305. 1868

This species is founded upon a single collection by Wright in Cuba, the types being at Kew. It is readily recognized by its peculiar goblet-shaped form, resembling a long-stemmed *Peziza* or a young stage of *Cantharellus cibarius*. Its substance is relatively quite thick, the depression at the center being shallow instead of deep as might be expected from its shape. The margin, if not straight, is rolled inward instead of outward, and the stipe is long, slender and undulate.

8. POLYPORUS CRATERELLUS B. & C. Jour. Linn. Soc. Bot. **10**: 305. 1868

The type collection of this species was made by Wright in Cuba. The name is well chosen and refers to a character by which the plant is easily distinguished from its near allies. Plants collected in Louisiana by Langlois are even more deeply infundibuliform than the types and are also somewhat larger. The species occurs on decaying wood and appears usually in small clusters.

9. POLYPORUS ACICULA B. & C. Jour. Linn. Soc. Bot. **10**: 304. 1868

This minute species is represented by a single specimen, two millimeters in diameter, collected on decayed wood in Cuba.

The stipe is long and slender, centrally attached and somewhat hairy at the base. The pileus is umbilicate with involute margin resembling a minute species of *Omphalia* in shape. In general appearance the plant resembles *P. Tricholoma*, but the margin is without cilia and the pores are alveolar.

10. POLYPORUS DISCOIDEUS B. & C. Jour. Linn. Soc. **10**: 303. 1868

This species was collected by Wright in Cuba. It is rather larger than most of the members of the genus, but resembles them closely in habit and structure. Its nearest ally is perhaps *P. virgatus*. Being large, it is rather fleshy, the context becoming soft, corky and elastic when dry. The tubes are rather large, at length sinuose, and become collapsed on drying, indicating a soft condition when fresh.

11. POLYPORUS PHAEOXANTHUS B. & Mont. Sylloge Crypt. 154. 1856

This rare species was collected at Columbus, Ohio, by Sullivant. It grew on fallen oak wood. The type at Paris is in fragments, but these are well preserved. The character by which the species is at once recognized is the deep yellow color of the context. The pileus is convex, reddish-brown, glabrous, scarcely a millimeter thick and about two centimeters broad; the stipe central and concolorous, the tubes minute and remote from the stipe.

12. POLYPORUS COLUMBIENSIS Berk. Lond. Jour. Bot. **1**: 454. 1842

This is one of the thinnest species of the family, resembling a brown cuticle stripped from some fruit having a smooth, waxy, polished coat. It is orbicular in shape with a dark central stipe and small decurrent tubes. The type was sent to Berkeley from the Columbia River region of South Carolina. There is also in the Berkeley herbarium a specimen from Chicalahi, Mexico, bearing the same name, which may be the same species.

13. POLYPORUS OBOLUS Ell. & Macbr. Bull. Iowa Univ. Lab. Nat. Hist. **4**: 68. 1896

A small plant with very thin partially translucent pileus, brown central stipe and exceedingly minute pores. Pileus orbicular, plane, 1.5–2.5 × 0.03–0.08 cm.; surface minutely tomentose, radiate-rugose, isabelline, fulvous at the center; margin straight or repand, even, glabrous, entirely devoid of teeth or cilia: context 0.2–0.7 mm. thick, tough, white, translucent, especially near the margin; tubes 0.1 mm. long, 8 to a mm., adnate, white, cylindrical, regular, edges thick, entire; spores ovoid, smooth, hyaline, 3.5–4 × 4.5–5 μ: stipe central, tough, elastic, slender, equal, chestnut-colored, glabrous, smooth, much compressed in drying, 2–4 cm. long, 1–2 mm. thick.

The above description of this species is made from dried plants now in the herbarium of the New York Botanical Garden, collected by C. L. Smith in Nicaragua.

Type plants kindly furnished me by Macbride agree in all respects with these, being a part of the same collection. The species is nearly related to *P. Tricholoma*, but the pileus is very thin and translucent, the margin entirely glabrous and the pores scarcely one eighth of a millimeter in diameter.

14. POLYPORUS AEMULANS B. & C. Jour. Linn. Soc. Bot. **10**: 304. 1868.

Very little is known of this species beyond the small type collection from Cuba and Berkeley's rather meager description. The types are well preserved, however, and show decided characters. They resemble *P. arcularius* in having alveolar tubes, but these tubes are broad and shallow and disappear near the margin, leaving a sterile marginal band one or two millimeters in diameter. In habit, the species resembles *P. Polyporus*. The whole plant is thin and tough, with brown central stipe.

15. **Polyporus arculariellus** nom. nov.

Favolus Curtisii Berk. Grevillea, **1**: 68. 1872.

One specimen only of this plant seems to have been sent to Kew by Curtis from his North Carolina collections. This is well preserved, however, and shows the very thin pellucid pileus ornamented around the margin with long cilia, the oblong favoloid tubes and the centrally attached tapering stipe that characterize the species. It is a near ally of *Polyporus arcularius*, though smaller and much more delicate, and also closely resembles such ciliated forms as *P. Tricholoma* and its near allies; so that its natural affinities appear to be with *Polyporus* rather than with *Favo-*

lus. It is unfortunate that the existence of a *Polyporus Curtisii* renders it necessary to change the species name in the transfer from one genus to the other.

16. POLYPORUS ARCULARIUS (Batsch) Fr.

Boletus arcularius Batsch, Elench. Fung. 97. 1783. (Mich. *pl. 70. f. 5.* 1729.)

Boletus exasperatus Schrad. Spic. 153. 1794.

Polyporus arcularius Fr. Syst. **1** : 342. 1821.

This species was described by Batsch as follows : "Stipitatus ; stipite subgracili, subclavato ; pileo membranaceo convexo, subulato-fimbriato ; stipiteque concoloribus, spadiceo-rufis ; cellulis latissimis, rhombeis, aequalibus albis." Fries placed it in the genus *Favolus*, which he treated as a subgenus under *Polyporus*. Its tubes are certainly favoloid, but its close relationship to *P. Polyporus* has kept it near this species rather than with species of *Favolus*. Wright's specimen of *P. lentus* from Connecticut seems nothing more than *P. arcularius*. There is at Kew also the remains of a specimen from Ohio, which very probably belonged in the same category.

P. arcularius shows little variation except in size throughout its wide range. It occurs on decaying wood and shows much the same habit as *P. elegans* and *P. Polyporus*, but differs from these species in occurring more abundantly in the south. Specimens have been examined from the following localities : Tyrol, *Bresadola ;* Connecticut, *Earle ;* Pennsylvania, *Everhart ;* New Jersey, *Ellis ;* Georgia, *Ravenel ;* Ohio, *James, Morgan ;* Missouri, *Demetrio ;* Nebraska, *Bates ;* Colorado, *Crandall ;* New Mexico, *Earle ;* Michigan, *Longyear ;* Kansas, *Bartholomew ;* Kentucky, *Price ;* Mississippi, *Ricker ;* Alabama, *Earle, Baker ;* Florida, *Rau, Calkins ;* Mexico, *C. L. Smith.*

17. **Polyporus variiporus** sp. nov.

A small plant resembling *P. Tricholoma*, but firmer and tougher with thicker stipe and more irregular pores. Pileus orbicular, convex to depressed, 1–2.5 × 0.1–0.2 cm., surface glabrous, more or less radiately striate, somewhat concentrically rugose, straw-colored to isabelline, fulvous to chestnut-colored around the margin, which is thin, inflexed, undulate, finely ciliate, the cilia being fugacious: context 1–1.5 mm. thick, tough, white; tubes 0.5 mm. in length, 2–4 mm. in diameter, very irregular, much elongated radially near the stipe or in marginal folds, not noticeably decurrent, yellowish, polygonal to lamelloid, edges firm, entire, becoming denticulate or fimbriate with age; spores ellipsoid, smooth, hyaline, $4 \times 7\,\mu$: stipe central, hollow, increasing above, lighter than the pileus, subglabrous with a silky luster, 2 cm. long, 2–6 mm. thick, the buried base enlarged, tomentose and frequently black.

This species was collected by Earle on his recent trip to Porto Rico. It grew on sticks buried in sandy soil in woods. The thick stipe and irregular tubes suggest *P. pachypus* of Montagne, but it is evidently not that species. It differs from nearly related ciliated forms in being conspicuously tougher and thicker with tubes that are in one place small, regular and polygonal and in another transformed by confluence into long sinuate furrows resembling the gills of an agaric. This transformation commonly occurs near the stipe or in pockets made by the partial folding of the pileus.

18. POLYPORUS TRICHOLOMA Mont. Ann. Sc. Nat. Bot. II. **8**: 365. 1837. Pl. Cell. Cuba, 249. *pl. 17, f. 1.* 1842

This species was originally well described and figured by Montagne and several specimens of typical plants are still in existence, so that no doubt exists concerning its identity. In addition to this, a large number of fresh specimens have recently been collected in Cuba and Jamaica by Earle and Underwood and some study made of the habits and variations of the species. It is found to grow in abundance throughout the West Indies and Central America, varying but slightly in color, but more in size and surface markings, occurring usually on dead sticks in woods, but sometimes upon logs and even on cocoanut husks. When seen in the fresh state it is commonly pure white and easily mistaken for some small agaric, but often with age and always in drying the color changes to pallid or light yellowish-brown, or even to a pale reddish-brown. The type plants were, of course, dried specimens and happened to be darker than is usual with the species.

Another variation still more marked and the cause of considerable confusion is in the size and persistency of the cilia around the margin of the pileus. Sometimes they are long and rigid, sometimes short and flexible; they usually disappear at early maturity, but occasionally persist until the plant has passed its prime. It is doubtful if Montagne himself knew of these variations, and it is certain that Berkeley was much confused by them. In dealing with the types of this plant it is best to consider the Cuban specimens only, since plants from elsewhere were later included in the species concept, which are in reality different things. Likewise, in examining Berkeley's specimens of *Polyporus similis*, one must confine himself to the Brazilian plants, since the Cuban ones are only *P. Tricholoma* with the cilia gone. In the same way *P. flexipes*, *P. stipitarius* and a few other species have undoubtedly become confused with *P. Tricholoma* in the minds of not a few mycologists and many collectors.

The following collections are in the herbarium of the New York Botanical Garden: Jamaica, *Earle 502, 592, Underwood 2953*; Cuba, *Underwood and Earle 246, 579, 744, 851*; Mexico, *C. L. Smith;* Nicaragua, *C. L. Smith;* Cozumel Island, *Millspaugh 1556.*

19. **Polyporus Cowellii** sp. nov.

A small light-colored plant resembling an agaric, having a very thin translucent context, minute pores and a slender central stipe. Pileus orbicular, convex to plane, umbilicate, 1–2 × 0.02–0.05 cm.; surface nearly glabrous, minutely concentrically rugose, straw-colored to isabelline, becoming darker and hygrophanous around the margin or in blotches or even over the entire surface, often faintly radiate-striate about the center with delicate white or brown lines; margin very thin, straight or inflexed, somewhat irregular in outline, finely denticulate, the teeth prolonged into short fugacious cilia: context extremely thin, membranous, 0.1–0.2 mm. thick, white or pallid, partially or entirely translucent; tubes 0.2–0.4 mm. long, 3–6 to a mm., larger by confluence, adnate, pallid, polygonal, edges very thin, subentire, becoming fimbriate with age; spores ellipsoid, smooth, hyaline, binucleate, 2.5 × 5 μ: stipe central, solid, very slender, equal, concolorous or slightly darker, pruinose to glabrous, smooth, longitudinally striate, 2–3 cm. long, 0.3–1 mm. thick, soft and milk-white at the center.

This species is described from dried plants collected in the island of St. Kitts by Britton and Cowell during September and

October, 1901. It was found in considerable quantity growing on decaying wood. There is also in the herbarium of the New York Botanical Garden another good collection of this species from Porto Rico made by Mr. and Mrs. A. A. Heller in March, 1899. It also grew on dead wood. This latter collection, however, is not considered typical.

20. POLYPORUS CAUDICINUS (Scop.) Murrill

Boletus caudicinus Scop. Fl. Carn. ed. 2, **2**: 469. 1772.
Boletus Juglandis Schaeff. Fung. **3**: 75. *pl. 101–102.* 1774.
Boletus squamosus Huds. Fl. Angl. 614. 1778.
Polyporus Ulmi Paul. Icon. Champ. *pl. 13.* 1793.
Polyporus squamosus Fr. Syst. **1**: 343. 1821.
Polyporus caudicinus Murrill, Jour. Myc. **9**: 89. 1903.

Exsicc.: France, *Roumeguère 2706, 2707, 3403*; Germany, *Krieger 860, Sydow 212, Magnus, Murrill;* Sweden, *Murrill;* England, *Murrill;* Canada, *Dearness;* Connecticut, *Underwood.*

This species is the largest of the genus and occurs in very conspicuous clusters on the trunks of injured deciduous trees in Europe and America. In London and in some of the cities of Germany I have found it especially abundant on elms, maples, horse chestnuts and other shade trees. It is at present comparatively rare in America and need not here be seriously considered from an economic standpoint for some years to come.

Scopoli's description is not so clear and definite as might be desired, but in the first variety described there can be no question as to the plant he had in mind, for he speaks of it as multiple, lobed, fleshy, large, growing on the trunks of trees, variegated above with darker spots, light-colored beneath, with large polygonal pores. The large pores connect it with the genus *Hexagona*, but its general structure and habit are those of *Polyporus.* Young plants collected in Connecticut, by Underwood, in May, showed very short favoloid tubes with thin toothed dissepiments, a milk-white fleshy-tough context and a scaly pileus differing little in color from that of the mature plant. The odor of the fresh plant is strong and somewhat mealy; the base of the stipe is clothed with short dark-brown or black velvety tomentum. It is quite possible that in this species we have modifications produced by an abundance of nutritious food such as is not supplied to the common species growing on dead wood. Large size, very rapid growth, ample pores and a somewhat softer context are probably connected with a better food supply and a more vigorous mycelium.

In addition to *Polyporus*, the present species has served as the nomenclatorial type of two recent genera, *i. e.*, *Cerioporus* Quél. (Ench. Fung. 167. 1886) and *Melanopus* Pat. (Hymenom. Eur. 137. 1887).

21. **Polyporus maculosus** sp. nov.

A small tough plant nearly related to *P. fissus*, but minutely tomentose, with rounded nearly glabrous spots of a reddish-brown color. Pileus irregularly orbicular, deeply depressed, 3–3.5 × 0.1–0.2 cm., surface finely and densely tomentose, radiately striate, drab-colored, ornamented with several light-bay or chestnut spots mostly situated about midway between the center and the margin, which is very thin, striate, irregular and somewhat fissured but entirely devoid of teeth or cilia: context 0.5–1.5 mm. thick, tough to corky, pallid; tubes 0.2–0.4 mm. long, 6–7 to a mm., decurrent, pallid or yellowish, subcylindrical, edges entire; spores ovoid, hyaline, smooth, $3 \times 4\,\mu$, immature in these specimens: stipe central, solid, woody, tapering upward, chestnut-black at the base with blotches of light-yellow, uneven, subglabrous, 2 cm. long, 2–4 mm. thick.

This plant was collected in Central America by C. L. Smith. The hymenium is not quite mature, but the other characters are well marked. The peculiar reddish spots seem to be caused by the disappearance of the thick tomentum at certain points. The species occurs on wood and has the habit of representative plants of this genus.

22. POLYPORUS ELEGANS (Bull.) Fr.

Boletus elegans Bull. Herb. France, *pl. 46.* 1780.

Boletus nummularius Bull. Herb. France, *pl. 124.* 1782.

Polyporus elegans Fr. Epicr. 440. 1836–1838. Pat. Tab. Fung. 137. 1883–1886.

Abundant throughout Europe and North America on decaying branches and trunks of various trees. Being exceedingly variable in form, it is not strange that in Europe it is confused with its variable near relative, **Polyporus Calceolus** (*Boletus Calceolus*

Bull.) [*Polyporus varius* (Pers.) Fr.], and some European mycologists go so far as to say that *P. elegans* and *P. Calceolus* are the same thing; but field studies in Sweden have convinced me that we have nothing in America to correspond to *B. Calceolus* of Bulliard, whose description and figure of this species may be easily matched with European specimens from either field or laboratory, while even our most closely allied Canadian forms of *P. elegans* fail to connect with the European relative.

The variety first described as *B. nummularius* by Bulliard is quite distinct from the typical form when seen in the herbarium, but when both are picked from the same branch in the woods the differences speedily become of minor importance. In the following partial list of specimens examined, no distinction is made between the two: Tyrol, *Bresadola;* Finland, *Karsten;* Canada, *Macoun*, *Dearness;* Vermont, *Burt;* Maine, *Ricker*, *Miss White;* Connecticut, *Earle;* New York, *Underwood*, *Cooke*, *Lobenstine;* New Jersey, *Ellis;* Ohio, *Morgan;* West Virginia, *Nuttall;* Michigan, *Ward;* Iowa, *Holway;* Colorado, *Bethel*, *Crandall;* Washington, *Piper*, *Parker*.

23. POLYPORUS FISSUS Berk. Lond. Jour. Bot. **6**: 318. 1847
Polyporus trachypus B. & Mont. Syll. Crypt. 154. 1856.

Both of the above names were assigned to plants sent from Ohio. Those sent by Lea were small and undeveloped and one or two were accidentally lobed. The tubes were so small as to be overlooked and he labelled them *Thelephora*. The collection made by Sullivant at Columbus was evidently described by Montagne. The description is accurate and quite complete. The reason why neither of these names has come into common use is due to the fact that our plant was at first miscalled *P. picipes*, a name given by Fries without good reason to plants of *P. calceolus* having particularly black stems. This latter species, so far as we are aware, does not occur in America, but American specimens at Kew are labeled *P. picipes* Fr. In the herbarium of Fries at Upsala there is only one specimen of "*P. picipes*" from North America and that is determined by Ellis. For our common species, then, which has been so generally known as *P. picipes*, we must make use of Berkeley's name.

The plant grows upon dead wood and has the habit of *P. elegans*, but is larger and darker in color. It often persists, however, until bleached nearly white. Exsiccati have been studied from Maine, *Harvey*, *Miss White*; Connecticut, *Underwood*; Massachusetts, *Seymour*; New York, *Clinton*, *Overacker*; Pennsylvania, *Everhart*; Vermont, *Farlow*; Kentucky, *Price*; Washington, *Parker*; Michigan, *Wood*, *Miss Minns.*

SPECIES INQUIRENDAE

Polyporus amygdalinus B. & Rav. Grevillea, **1**: 49. 1872. This species is said to differ from *P. caudicinus* in having smaller tubes, but it is probably only a form of that species in an undeveloped stage. I have not been able to find a type specimen.

Polyporus cyathiformis Lev. Ann. Sci. Nat. Bot. III. **2**: 181. 1844. The type of this species was probably burned with most of Leveillé's types during the occupation of Paris by the Germans. The description corresponds closely with *P. craterellus*, but it is difficult to determine that the two species are identical.

Polyporus pachypus Mont. Pl. Cell. Cuba, 421. 1842. This species is described as caespitose, with thick excentric stipe and membranaceous tubes, which are small and rounded near the margin and large and favoloid near the stipe. No types have been found in foreign herbaria and Montagne himself said in his *Sylloge* that the species needed further investigation.

Polyporus stipitarius B. & C. Jour. Linn. Soc. Bot. **10**: 304. 1868. The original description just cited does not materially assist one in interpreting the type plants in the Berkeley herbarium. Most of these types so closely resemble *P. Tricholoma* that a new description of them seems superfluous; and the one card of specimens which appears to be somewhat different from the rest was listed under *P. Tricholoma* by Berkeley at the time that *P. stipitarius* was described. Judging from the Kew collections, *P. stipitarius* appears to differ from *P. Tricholoma* chiefly in possessing a longer stipe, yet the description calls for a stipe shorter than that of *P. Tricholoma.* New material may possibly throw light on this problem, but I seriously doubt if Berkeley's species can ever be entirely disentangled from the earlier one of Montagne.

Polyporus gracilis Kl. Ann. Nat. Hist. **3**: 384. 1839. This is a caespitose species with slender pruinose stipe, small pellucid pileus, ciliate margin and very minute polygonal or sinuose tubes. Saccardo considers it the same as *P. flexipes* Fr. and *P. hapalus* Berk., but these two species do not, so far as I know, occur in the West Indies or even in Central America.

Polyporus Humphreyi P. Henn. Hedwigia, **37**: 280. 1898. From the description of this species it appears to resemble *P. Tricholoma*, but has adnate instead of decurrent tubes with whitish fimbriatulate edges. This and the next species are placed here because I have not yet examined the type specimens.

Melanopus marasmioides Pat. Bull. Soc. Myc. France, **18**: 173. 1902. This species is found in Guadeloupe and Martinique and is related to *Favolus melanopus.* It is deeply umbilicate, ochraceous, with translucent denticulate margin, which is sterile below, large shallow radiating tubes and a black central stipe. Undeveloped plants resemble certain species of *Xylaria.* An examination of the plant is necessary to determine whether or not it properly belongs with *Polyporus.*

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THE SPINES OF FOUQUIERIA

By WINIFRED J. ROBINSON

NEW YORK
1904

[Reprinted from BULLETIN OF THE TORREY BOTANICAL CLUB, **31**: 45-50. January, 1904]

[From the Bulletin of the Torrey Botanical Club, 31 : 45-50. January, 1904]

The spines of Fouquieria *

Winifred J. Robinson

The six species now comprised in the genus *Fouquieria* occupy collectively a region extending from the vicinity of the City of Mexico northward into California, Arizona, New Mexico and Texas. Nearly all of the species find their habitat in arid districts, and the localities from which they have been reported may be comprised within the southern extensions of the Chihuahuan and Sonoran deserts. Among other adaptations, the various species exhibit a capacity for casting off the leaves during seasons of drought, more or less irrespective of the time of the year, while some interesting features of the formation and casting away of the bark have been noticed.

All of the species bear strong spines and seem to be included under the single colloquial name "ocotillo" by the Mexicans, who use the living plants for hedges and sometimes erect barriers by thrusting the ends of heavy branches into the ground in rows. Messrs. Coville and MacDougal report having seen shrubs of *Fouquieria splendens* planted within a few inches of young shade trees in the streets of Alamogordo, New Mexico. The spreading spiny branches were held in a cylindrical clump around the trunk of the tree by means of wire and formed a most effective protection against damage by animals.

During the course of some recent work upon this genus, Mr. G. V. Nash called my attention to the unusual manner in which the spines were formed, which he described as "developed within the petioles of the leaves on the new growth, becoming apparent when these fall." † The general anatomical facts presented seemed of sufficient interest to warrant a detailed examination, and the results of my observations upon *Fouquieria splendens* and *F. Macdougalii*, specimens of which are growing in the conservatories of the New York Botanical Garden, are presented below.

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* The results described in the following paper were obtained by the aid of a Research Scholarship in the New York Botanical Garden, in 1903.

† Nash, G. V. A revision of the family *Fouquieriaceae*. Bull. Torrey Club, **30** : 449. 1903.

On the lower side of the petiole of the primary leaves, a woody thickening is developed (FIGS. 11 and 12, *w*) which increases in firmness as the leaf matures. This arises from the cortex, which even in the bud is proliferated to form a thickened area on the outer side of the base of each leaf (FIG. 1, *c*). As the leaf emerges from the bud a conical portion of the cortex on the lower side of the petiole begins to lose its parenchymatous character. The cells lengthen, their ends become pointed (FIG. 2, *s*) and their walls thicken; these changes are accompanied by a diminution in their lumina (FIG. 3, *s*). With phloroglucin and hydrochloric acid they take the violet color characteristic of sclerenchymatous cells. The conversion of the parenchyma into sclerenchyma is incomplete in *F. splendens*, and a slender cone shaped mass of thin-walled cells extends about two thirds of the distance from the base toward the tip of the newly formed spine. This is illustrated by the diagrams of longitudinal and transverse sections shown in FIGS. 4, 6 and 7, *p*. About the time when the leaf-blade is cast off, the parenchyma-core disintegrates and a hollow spine remains. In *Fouquieria Macdougalii*, on the other hand, almost the entire mass of the cortex on the outer (lower) side of the petiole is transformed into sclerenchyma, making a solid heavy spine (FIGS. 5 and 8, *s*).

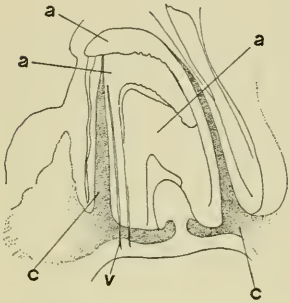


FIG. 1. Section through bud. *a*, young leaf; *c*, cortex, thickened to form spine; *v*, vascular tissue.

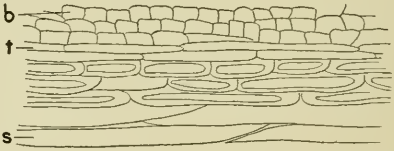


FIG. 2. Portion of longitudinal section through petiole. *b*, cortex; *t*, separating layer; *s*, sclerenchyma.

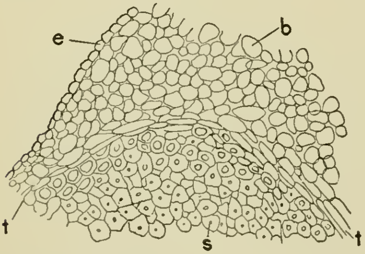
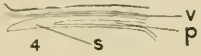
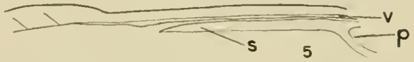


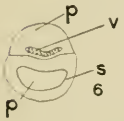
FIG. 3. Portion of transverse section through petiole.

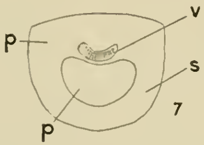
The growth of the leaf and the development of the spine is accompanied by the differentiation of a separatory layer of thin-walled, elongated cells (FIGS. 2 and

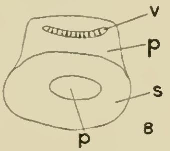
3, *t*) in the cortex, between the sclerenchymatous tract and the fibrovascular tissue of the petiole. The sclerenchymatous tissue sustains only mechanical relations to the leaf, and the lamina may be held for extended periods after the completion of the separatory layer. When the vegetative season reaches its end by reason of drought or low temperature, the leaf-blade is cast off; and as its fall occurs simultaneously with its drying out, this desiccation may be taken as the direct cause of the splitting of the separatory layer above mentioned. The separation is identical with that which occurs in the fall of the leaves of many deciduous trees in the autumn in general procedure, but the author is not acquainted with any other instance in which the petiole is cut in a longitudinal plane making necessary a separatory layer two or three centimeters











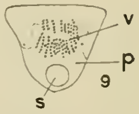


FIG. 4. Diagram of longitudinal section through petiole of *Fouquieria splendens*. *p*, parenchyma; *s*, sclerenchyma; *v*, vascular tissue.

FIG. 5. Diagram of longitudinal section through petiole of *Fouquieria Macdougalii*.

FIG. 6. Diagram of transverse section through petiole of *Fouquieria splendens* near the apex of spine.

FIG. 7. Diagram of transverse section through petiole of *Fouquieria splendens*, near base.

FIG. 8. Diagram of transverse section through petiole of *Fouquieria Macdougalii* near base.

FIG. 9. Diagram of transverse section through petiole of *Fouquieria Macdougalii* near the apex of spine.

in extent (FIG. 13, *d*). Again, this unique method of excision results in leaving an elongated pointed portion of the petiole 3 or 4 cm. in length attached to a mass of thickened epidermis and cork on the stem where it is retained rigidly for an indefinite period. The spine and the contiguous portion of the outer tissues of the stem may easily be pulled from the underlying tissues in *Fouquieria Macdougalii* (FIG. 10, *k*) when they are young, but in *F. splendens* they are less yielding.

In *Idria*, another genus of the same family, a similar spine, originating in the petiole of the leaf, has been described by Poisson (Bull. Mus. Hist. Nat. **1**: 278. 1895) and in some species of the nearly related *Cantua*, of the *Polemoniaceae*, there is a woody ridge at the base of each node. The latter, however, is more like the structure which protects the axillary bud in *Syringa* and *Philadelphus* than the spines of the *Fouquieriaceae*.

The majority of the buds in the axils of the primary leaves do not elongate to form branches, but develop small clusters of spatulate leaves which are almost sessile and do not form spines (FIGS. 11 and 12, *c*).

Engelmann (Bot. Gaz. **8**: 338. 1883) was the first to call attention to this peculiar mode of dehiscence of the leaves of *Fouquieria*. Plank (Garden & Forest, **9**: 73. 1896) says: "The bases of the spines appear to arise in the cellular part, leaving the wood full of holes in their decay," which statement was doubtless made because of the peculiar growth of the cork between the spines and the portions of the outer tissues, which adhere to them, making the spines, with their adhering pieces of bark, dry, papery structures, which still have close enough contact with the adjacent cells to leave a scar when they drop off. Van Tieghem

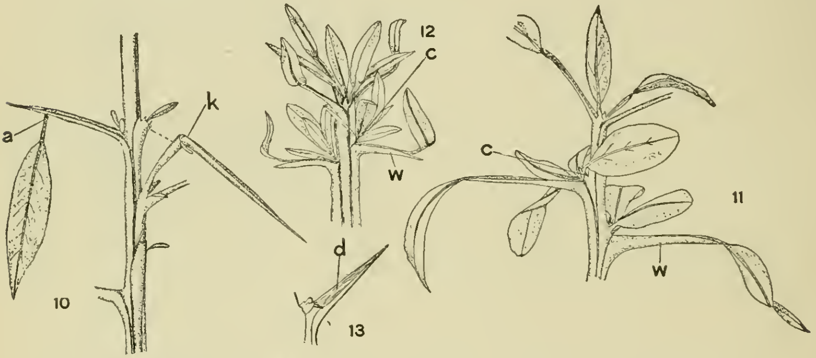


FIG. 10. *Fouquieria Macdougalii*, showing *a*, manner of dehiscence of leaf; *k*, manner in which spine and bark may be peeled from stem.

FIG. 11. Young shoot of *Fouquieria Macdougalii*. *c*, cluster of secondary leaves; *w*, thickening which will form spine.

FIG. 12. Young shoot of *Fouquieria splendens*.

FIG. 13. Spine of *Fouquieria Macdougalii*. *d*, surface from which upper portion of petiole has separated.

(Jour. de Bot. **13**: 295. 1899) has described the leaves of the long branches as having sclerenchymatous cells prolonged from the sclerenchymatous layer beneath the epidermis of the stem, on the under side where the epidermis is in contact with the cortex. He considers this subepidermis as the outer part arising from the division of the cortex into two well-differentiated layers, and criticises Baillon (Hist. Pl. **9**: 242. 1888) for referring to the spines as leaves reduced to a midrib. Such a section as that shown in diagram in FIG. 9, where there are several layers of parenchymatous cells between the sclerenchyma (*s*) and the epidermis, shows that the sclerenchymatous cells arise not from a distinct outer layer of the cortex, but within the cortex. Like the prickles of the blackberry and rose, the spines of *Fouquieria* have no vascular tissue, but unlike them, the sclerenchymatous tissue arises from the cortex, not from the cuticle and the abscission layer is nearly at right angles with the axis of the stem instead of being parallel with it and in the surface of the stem.

Various questions naturally arise in the study of such a structure as the spines of the *Fouquieriaceae*. How did these spines originate? Was the stimulus external or internal which caused the original variation? Is *Fouquieria* a genus that was separated from its parent form at a remote period, so that the intermediate forms between it and the other *Polemoniales* have become extinct, or is it a relatively new genus? Is it a stable form, or do the different plants vary in wide range?

Spinose processes are so characteristic of desert flora that the inference was long ago drawn that there is a close association between their structure and environment. The usual corollaries of spine development, reduction in surface and elaborate adaptations for water-holding, as well as the protective character of the spines themselves in warding off the attacks of animals, are such important factors in the maintenance of a genus in arid regions, that it is easy to reason that they are the outcome of influences in those localities external to the plant.

Kerner, Henslow, and others of the older botanists have been inclined to emphasize the principle that "specific forms, on the whole, fit the places they have to live in," rather than their inherent tendency to variation. No experiments have been performed upon

Fouquieria to test the effect of changed climatic conditions upon it, but it has been observed that in greenhouses the leaves remain attached to the plant a number of months, while in nature they are usually cast off at the end of a few weeks ; and in some years, in the wild state, no leaves are produced. Lothelier's experiments upon the barberry (Rev. Gén. Bot. **2** : 276. 1890) showed that when grown in moist air it loses its spines. Henslow (Jour. Linn. Soc. Bot. **30** : 223. 1895) has made a similar observation for *Ononis spinosa*, one variety of which living upon sandy shores is covered with spines, but becomes less and less spinose in favorable conditions or under cultivation, and he cites the cultivated apple and pear as similar examples. Miss Dale (Ann. Bot. **15** : 59, 497. 1901) has noted that when tubers of *Dioscorea* sent out shoots in light and without moisture, the leaves were scarcely developed at all, and the same thing may now be observed in the Museum of the New York Botanical Garden, where tubers of *Dioscorea* in the exhibition cases have sent out branches, the leaves of which are greatly reduced.

There is a wide gap between *Fouquieria* and *Cantua*, its nearest relative among the *Polemoniales*, which fact together with the small number of species in the genus, its confinement to a limited area, and its stability may be taken to indicate that it is an old form, though there is no geological record so far as is known of any similar spine-bearing form.

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